4.0 POPULATION AND HUMAN HEALTH

4.1 Introduction

The 2014 EIA Directive (2014/52/EU) has updated the list of topics to be addressed in an EIAR and has replaced 'Human Beings' with 'Population and Human Health'. The 2014 Directive does not provide specific guidance on the meaning of the term Human Health but it is considered a broad factor that is highly project specific covering the existence, activities and health of people, usually considering people as groups or 'populations'[1].

While most developments by people will affect other people, this section of the EIAR concentrates on those topics which are manifested in the environment, such as land use and patterns and employment.

It is noted that there are inter-related environmental topics described throughout this EIAR document which are also of relevance to Population and Human Health. Issues such as the potential likely and significant impacts of the proposed development on the landscape, biodiversity, archaeology & cultural heritage, air quality & climate, noise & vibration, water, land & soils, material assets including traffic & transport and built services are of direct and indirect consequence to human health. For detailed reference to particular environmental topics please refer to the corresponding Chapter of the EIAR. In accordance with EPA advice, the potential for the proposed project to result in significant impacts on Population and Human Health has been assessed with regard to the following topics relating to population and health-

- Land use and settlement patterns
- Population and Housing Supply
- Employment
- Community Infrastructure Capacity
- Human Health and Wellbeing

This Chapter of the EIAR will address the potential significant impacts, if any, of the proposed residential led mixed use development on population and human health under these topics. For a full description of the project please refer to Chapter 3.

4.2 Study Methodology

This Chapter of the EIAR has been prepared with reference to the document produced by the European Union, 'Environmental Impact Assessment of Projects Guidance on the preparation of the Environmental Impact Assessment Report (Directive 2011/92/EU as amended by 2014/52/EU)' (EU, 2017) as well as National Guidelines which provide guidance on the 2014 EIA Directive including the 'Guidelines for Planning Authorities and An Bord Pleanála on carrying out Environmental Impact Assessment' (2018) and the 'Draft Guidelines on the information to be contained in environmental impact assessment reports', published by the EPA in August 2017 as well as Draft Advice Notes for preparing Environmental Impact Statements (September, 2015).

[1] EPA Advice Notes

To establish the existing receiving environment / baseline, site visits were undertaken to appraise the location and likely and significant potential impact upon human receptors. Desk based study of published reference documents such as Central Statistics Office Census data, CSO online Statbank, Pobal online services, the National Planning Framework, the Regional Spatial and Economic Strategy for the Eastern and Midland Region as well as the Offaly County Development Plan 2014-2020 and the Tullamore Town and Environs Development Plan 2010-2016 (as varied and extended).

4.2.1 Principal Receptors

In terms of sensitive receptors that may be potentially impacted by the construction and operational stage of the proposed development, there are two existing residential developments located of Clonminch Road called Clonminch Wood and Limefield as well as the single dwellings on their own plots with direct frontage onto Clonminch Road to the south of the proposed vehicular entrance and the south west of the proposed development. Residential properties fronting Clonminch to the north of the application site are not considered a sensitive receptor as the development site is at a distance from these and there is existing development between these properties and the application site. In addition the various EIAR studies did not identify these properties as sensitive receptors. No major development works are planning as part of the undertaking of the improvement works to this road, which will be managed in accordance with the Construction Management Plan and they are at distance from the main development area. The cycle lanes will be provided primarily by adjustments to road markings. Other potential receptors of impacts include transient populations such as car drivers, walkers, cyclists and train passengers travelling on the rail line to the east and north east of the application site, though at some distance.

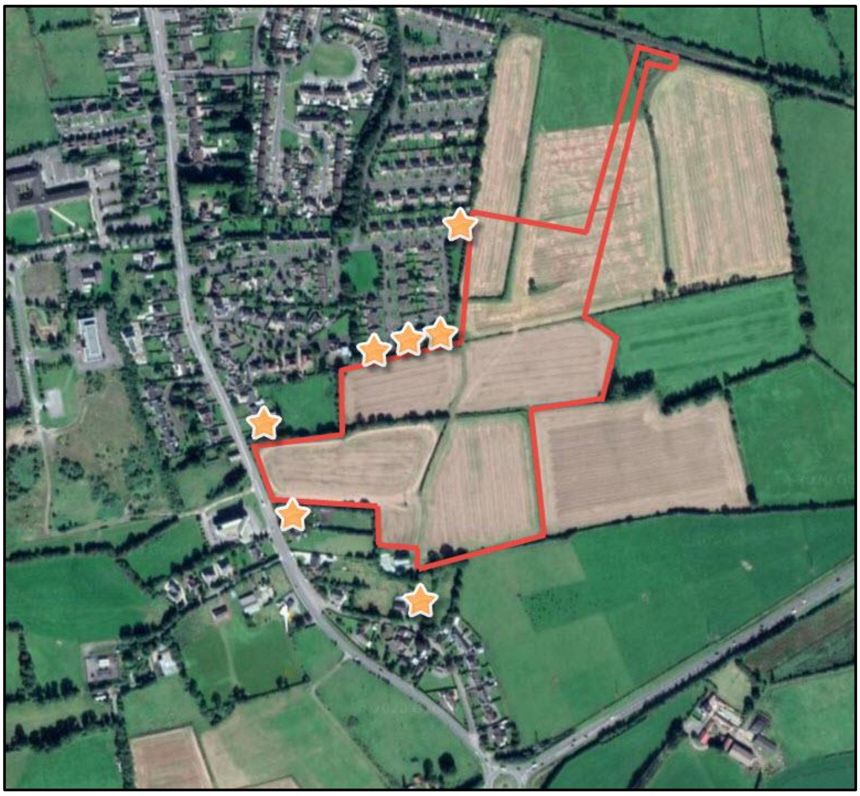


Figure 4.1– Sensitive Receptors

4.3 The Receiving Environment – Baseline Scenario

4.3.1 Land Use and Settlement Patterns

The development lands are located in the townland of Clonminch within the Southern Environs of Tullamore, and extend to an area of approximately 14.3 hectares with a net development area of 10.8 hectares. The lands are contiguous with the existing surrounding residential development in the area.

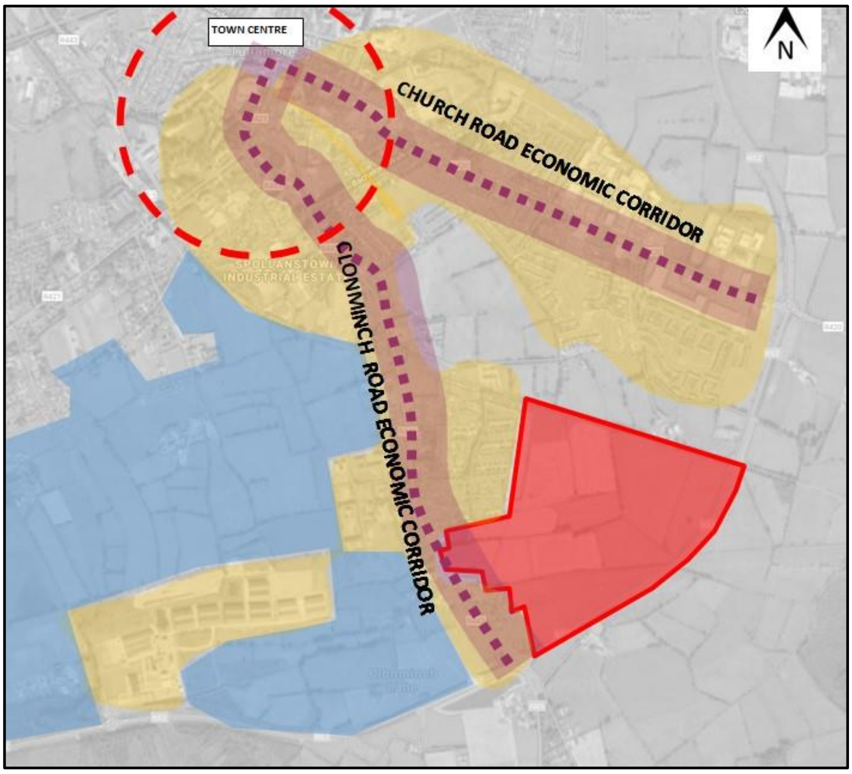


Figure 4.2 – Settlement Pattern

Existing Development Footprint
Southern Environs Development Area
Eastern Node

The lands are currently in agricultural use. The immediate area can be described as semi-urban, featuring existing residential development to the west and south west and the main Dublin-Galway train line to the east and the N52 ring road to the south.

The development area is zoned 'Residential' and 'Neighbourhood Centre' by the Tullamore Town and Environs Development Plan 2010-2016 (as varied and extended). The area in which the site is located forms part of the wider Southern Environs Masterplan lands and sub-division called the Eastern Node. Planning permission has been granted for 19no. houses to the north of the vehicular entrance under Part 8 by Offaly County Council.

4.3.2 Population and Housing Supply

Tullamore is situated in the Midlands of Ireland and is County Offaly's primary urban centre. The Tullamore Town and Environs Development Plan 2010-2016 notes the population of the town and environs in 2006 was 12,927, which represented a 16.5% population increase between 2002 and 2006 and a 22.3% increase between 1996 and 2006. According to the Offaly County Development Plan 2014, Tullamore had a population of 14,361 in 2011 which again shows growth within the settlement (11%).

Small Area Population Statistics for the settlement of Tullamore show that of the 4,732 households who stated the year their house was built, only 0.7% were built in the period 2011 or later compared to 35% built between 2001-2010, which reflects the downturn in the economy and lack of supply of new housing stock in Tullamore over the last ten years. There has also been little population growth within the settlement shown by the Census 2016 which records Tullamore with a population of 14,607.

The Offaly County Development Plan 2014-2020 has allocated 1,921 residential units to Tullamore and its environs for the period 2014-2020 based on an average house size of 2.9 persons. This projected demand was in line with the status of Tullamore in the Midland Regional Planning Guidelines. While statistics are not available at the settlement level for dwellings completions, the CSO records that there have been 759 new dwelling completions in the area of Offaly County Council between 2014-Q1 2020. This represents 24% of the total number of units required within the County to meet projected need stated by Table 1.3 of the County Plan. Unfortunately figures are not available for the individual urban centres within the County, however the figures clearly show that housing completions are falling significantly short of the requirements of the County Development Plan. It is also worth noting that 65% of the new dwellings completed between 2014 and Q1 2020 are categorised as 'single house' meaning that the majority of completions were probably not even on the market.

Census 2016 records for private households by type of accommodation for Tullamore clearly show that the majority of housing in Tullamore (91%) consists of traditional houses. Looking to potential supply, an examination of planning permissions granted for new houses and apartments in Offaly over the last five years (2015-Q12020) indicate that 92% of units were houses and 8% were apartments (Figure 4.3 illustrates). Of the 1,323 houses granted planning permission from 2015-Q12020, 42% were one off houses.

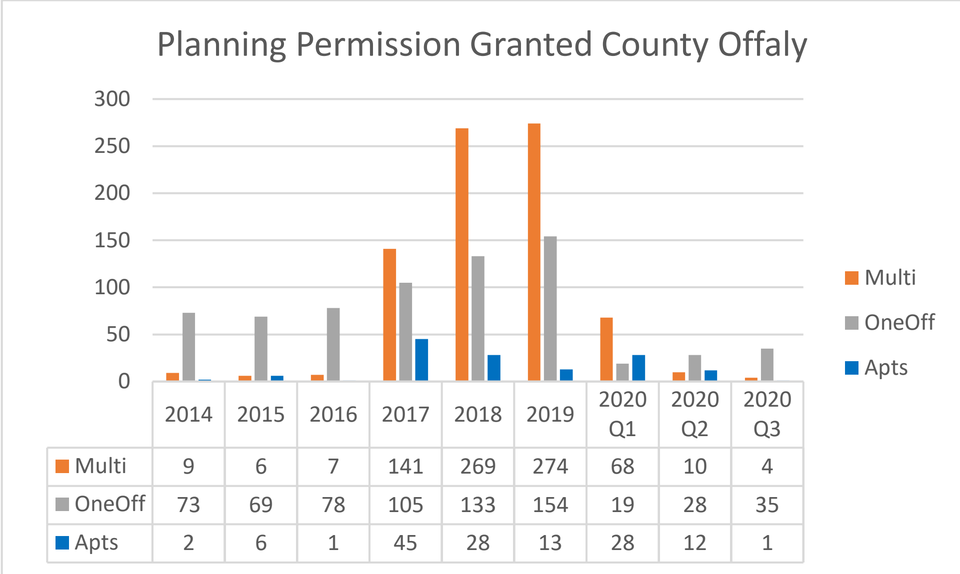


Figure 4.3 – Split between houses and apartments granted planning permission

4.3.3 Employment and Commuting Pattern

The National Planning Framework (NPF) was published in May 2018 and is the Government's high-level strategic plan for shaping the future growth and development of our Country out to the year 2040. Appendix 2 of the NPF records Tullamore with a total of 5,549 resident workers and a jobs to resident workers ratio of 1.488. This can be seen in the travel to work, school or college patterns recorded by the Census 2016 which record 77% of people over 5 years who stated how long their journey took them, spent less than half and our getting to their destination.

The importance of Tullamore as a key employment centre for the surrounding hinterland is recognised by the Regional Spatial and Economic Strategy (p.82) and is clear in the positive commuter flow pattern which recorded 5,329 commuters who travelled to Tullamore to work each day in 2016.

Using Census 2016 data for the settlement of Tullamore, the population aged 5 years and over that commute on foot in Tullamore is above the national average (14%) at 20%. However, car usage is slightly higher than the national average (60%) at 65%.

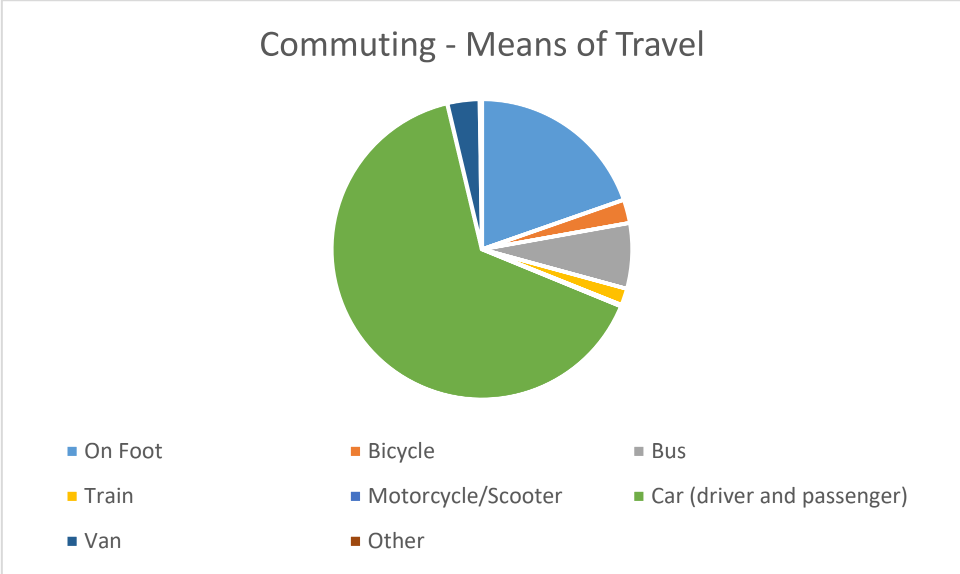


Figure 4.4 - Means of Travel to School and Work

Using statistics from Central Statistics Office-Small Area Population Statistics for Tullamore Settlement; of the total population aged 15 years and over of the area (11,288), 1,268 (11%) were unemployed having lost or given up a previous job, and 5,637 (50%) were at work while a further 10% were students. The occupations with the highest recorded persons were professional occupations followed by skilled trades. 25% of persons at work were categories as 'Professional Services' with a further 21% in 'Commerce and trade' industries. Together with the fact that 48% of the population 15 years and over have higher education qualifications beyond secondary school clearly implies that Tullamore could be an attractive location to employers.

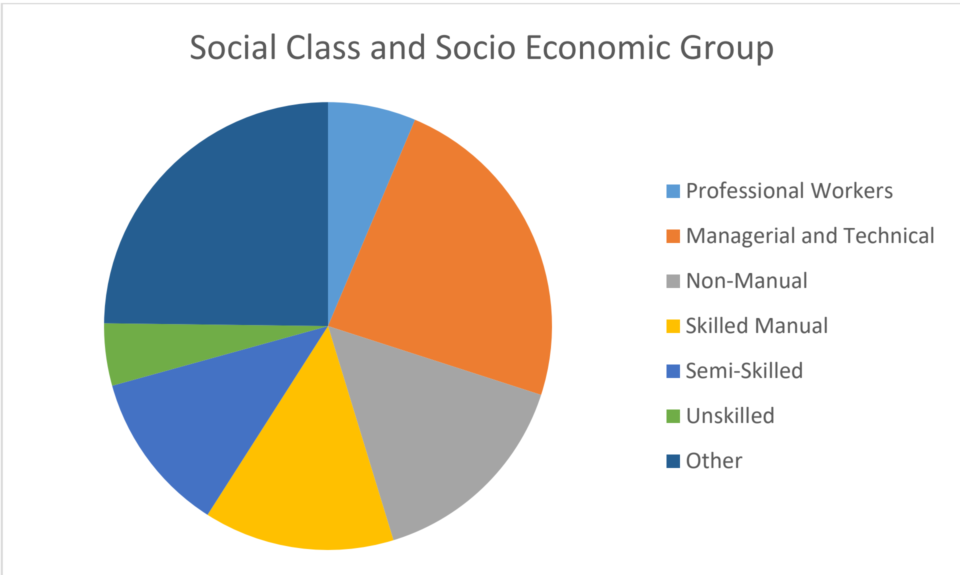


Figure 4.5: Social Class and Socio Economic Group of population gainfully occupied (Census 2016)

4.3.4 Community Infrastructure Capacity

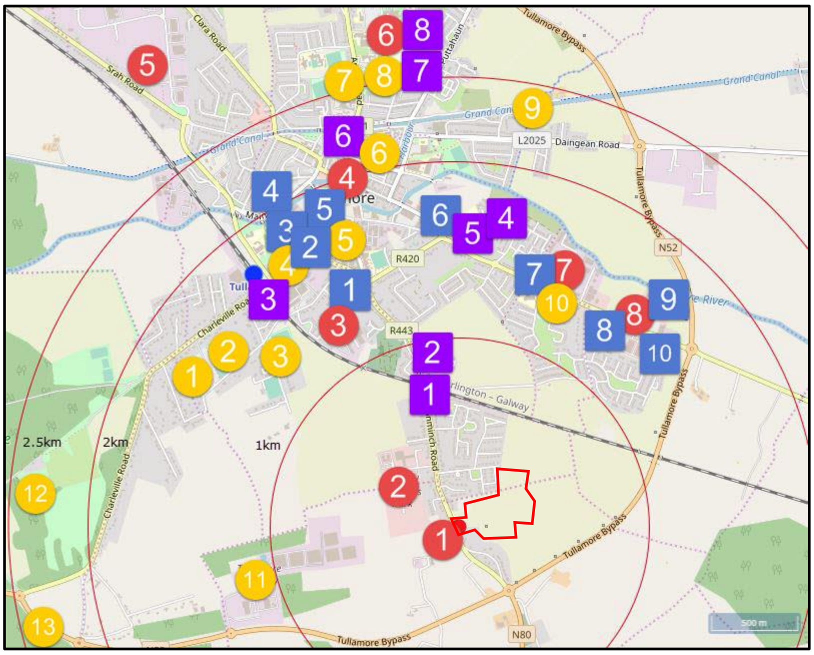


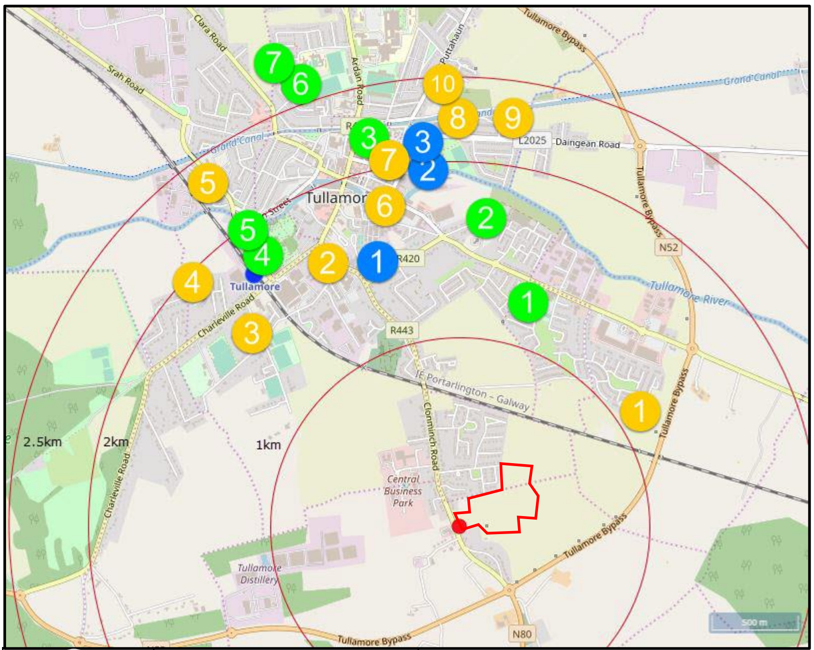
Figure 4.6 – Audit of Community Services and Amenities within 2.5km of application site

Retail and Services			
1	Tullamore Court Hotel	6	Dunnes Stores
2	The Bridge Centre	7	Spar
3	Central Hotel	8	Tullamore Retail Park
4	Lidl	9	Riverview Commercial Park
5	Bridge House Hotel	10	Tesco Extra
Enterprise and Employment			
1	Clonminch House	5	Srah (IDA) Industrial Estate-
2.	Central Business Park	6	Midlands Regional Hospital
3	Spollenstown Industrial Estate	7	Cloncollig Industrial Estate
4	Town Centre with associated offices, retail and service industry employment.	8	Tullamore Retail Park
Sports, Recreation and Leisure			
1	Tullamore Harriers Athletics	8	O'ConnorPark
2	Astroturf Pitches	9	Grand Canal Walk
3	Tullamore Rugby Club	10	Aura Tullamore Leisure Centre&Tennis
4	Lloyd Town Park	11	Tullamore Dew Visitors Centre
5	IMC Cinema	12	Charville Forest & Castle
6	Library	13	Tullamore Golf Club
7	Tullamore GAA		
Community/Health Services			
1	Community Pharmacy	5	Charville Community Centre
2	Offaly Centre for Independent Living	6	HSE Community Health Centre
3	Offlay County Council	7	The Health Centre
4	Tullamore Primary Care Centre	8	Midland Regional Hospital Tullamore
T	Transport – Train Station and Bus Station		

Table 4.1

Tullamore is placed at Level 2 of the Retail Hierarchy by the RSES and the proposed development will be well catered for with shopping, sports and health facilities within a 2.5km radius as illustrated by figure 4.5 above. For day to day local needs the proposed neighbourhood centre would reduce the need to travel by car to the town centre while the local bus route provides access to the Tesco, Aldi and retail park on the R420 to the north east of the site.

Figure 4.7 – Location of Schools and Childcare Facilities



Childcare Services
Primary School
Secondary School

	Childcare Services
	Primary School
	Secondary School

Primary Schools Enrolment (2020-2021)				Secondary Schools Enrolment (2020-2021)			
No.	**School**	**Boys**	**Girls**	**No.**	**School**	**Boys**	**Girls**
1	Gaelscoil an Eiscir Riada	99	113	**1**	Colaiste Choilm	619	N/A
2	Charleville National School	50	50	**2**	Tullamore College	296	384
3	St. Philomena's National School	N/A	178	**3**	Sacred Heart Secondary School	N/A	543
4	Scoil Mhuire	80	220				
5	Scoil Bhride	155	N/A				
6	St. Joseph's National School	222	177				
7	Arden Boys	202	N/A				
	Sub-Total	**808**	**738**		**Sub-Total**	**915**	**927**
8	Offaly School of Special Education	**34**					
	Total	**1,580**			**Total**	**1,842**	

Childcare Facilities					
No.	**Facility**	**Capacity**	**No.**	**Facility**	**Capacity**
1	Little Caterpillars	22	**6**	ABC Nursery & Playschool	32
2	Early Years Childcare	27	**7**	Naíonra Gaelach An Tulach Mhór	24
3	A Little Treasures Montessori Preschool	22	**8**	Re Scoil Isoagain	22
4	Little Acorns Pre-School	28	**9**	Happy Hours	31
5	Castleview Pre-School	10	**10**	Little Trinity Montessori	52
				Total	**270**

Table 4.2

There are a number of both primary and post-primary schools located within the area. Using data provided by the Department of Education and Skills on individual schools (Primary Schools 2020-2021 and Post Primary Schools 2020-2021) it is possible to establish the current number of students in existing schools in the area. This is set out in Table 4.2. Pobal records indicated there are 10no. childcare facilities within 2.5km of the subject lands.

Tullamore is well served by public transport with the Train Station located to the north in the town centre with interconnecting bus routes both local and regional extending along the main roads. The local bus service No. 835 stops to the north of the application site and provides a service to the train station, town centre, Tullamore Hospital and the Retail Park to the east on the R420. As part of the Part 8 residential development to the north of the application site entrance, an agreement has been made to move an existing bus service to this location.

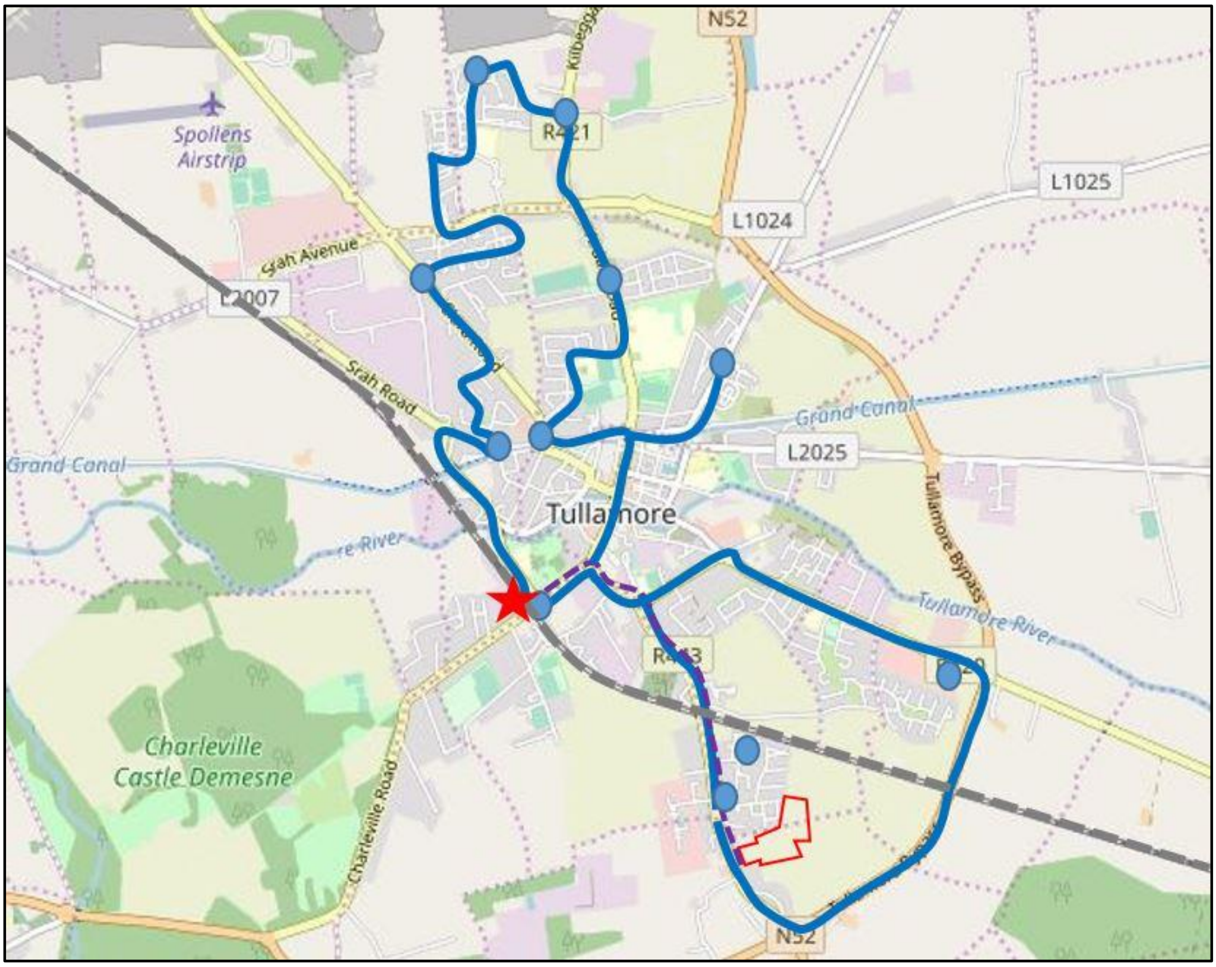


Figure 4.8 – Site Location relative to Public Transport Routes

Local Bus Route 835 Bus Stop Train Station

Train Line Footpath to Train Station

4.3.5 Human Health

The Pobal HP Deprivation Index is a method of measuring the relative affluence/ disadvantage of an area using various census information. The scoring is based on a national average of 0 and ranges from -35, this being the most disadvantaged to +35, this being the most affluent.

Using the online Pobal Maps viewer, the electoral Division for Tullamore Urban shows Tullamore to be marginally below average at -6.25. The Deprivation Index by Small Areas shows that there are areas of contrast surrounding the application site with areas of affluence (+11.91) beside others that are disadvantaged (-19.98).

Census 2016 records the general health of the majority of population in Tullamore is good to very good (88%).

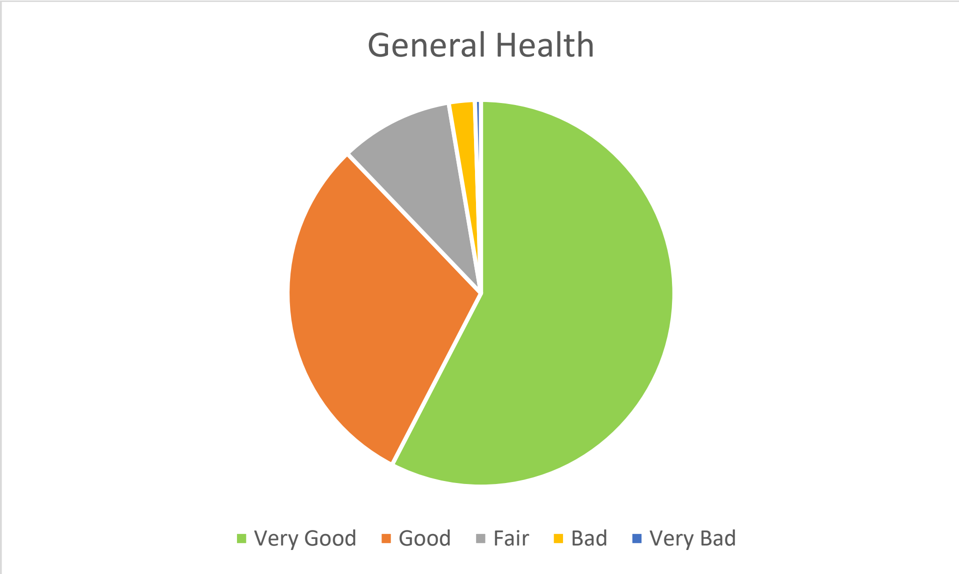


Figure 4.9 – Population by General Health

4.4 'Do Nothing Scenario'

In the do-nothing scenario, the proposed project would not occur and the lands would remain undeveloped and in agricultural use.

In the do-nothing scenario, potential employment opportunities within the area will be lost both at construction and operation stages.

The do-nothing scenario is found to a disadvantage in terms of population and human health.

4.5 Cumulative Impacts

The cumulative impacts of the proposed development has been considered with other approved projects in the area. A development of 19no. dwellings has been permitted under Part 8 by Offaly County Council and has commenced construction to the north of the application site entrance via a separate vehicular entrance onto Clonminch Road. The primary source of potential cumulative impacts on human health would be during the construction phase in terms of air quality, noise and vibration. As this development has commenced construction there should be no overlap in construction phases. The potential cumulative impacts during the operational phase have taken cumulative impacts into consideration in the analysis of potential traffic generated both by the proposed development, permitted development to the north of the application site and in the sensitivity analysis. Please see the relevant chapter for further details.

In terms of land use and settlement patterns, population and housing supply, the development of 19no. houses for the elderly currently under construction to the north of the application site will further consolidate this established residential area and add to the mix of residential dwellings available to the population of Tullamore. This is seen as a positive impact.

4.6 Likely Significant Effects on Receiving Environment

4.6.1 Land Use and Settlement Patterns

The proposed project will change the land use from agricultural lands to a new residential neighbourhood area. This semi-urban area is surrounded by large scale infrastructure and existing residential developments. The lands are appropriately zoned and contiguous to the urban area of Tullamore. This is a permanent moderate effect but will be positive as it will consolidate the urban area.

4.6.2 Population and Housing Supply

Using statistics from the Central Statistics Office, it is calculated that the average household size for the Tullamore Settlement Area is 2.7 persons per household. Given the proposal contains 349 residential units, it could accommodate a population of 942 persons. Population growth is a key priority for the settlement under the RSES (p.82). The proposal would assist in the achievement of a population as envisaged by the Regional Guidelines. This is seen as a moderate positive impact.

The Settlement of Tullamore in which the site is located is recorded in 2016 has having a population of 14,607 and housing stock of 5,306. The proposed development represents a 6.7% increase in housing stock Tullamore. In addition, the proposed development will add variety to the existing and permitted housing stock of Tullamore with 44% of the units proposed as apartments. The additional housing units will have a permanent and positive impact on the housing stock levels in Tullamore.

4.6.3 Employment and Commuting Pattern

The proposed development will provide for additional employment in the area during both the construction and operational phase. This will have a moderate positive impact on the local economy with the creation of new jobs, reducing levels of unemployment in the area and supporting the resident workers to jobs ratio.

It is estimated that approximately 100 direct jobs created during the construction phases, with additional "spin-off" economic and employment benefits also generated.

The crèche facility has been designed to accommodate up to 100 children. Childcare Regulations[2] require strict child to adult ratios and based on these, it is estimate this facility could provide jobs for 20 members of staff. It is estimated that the neighbourhood units with medical centre could provide employment for 100no. workers based on a conservative allocation of 1 employee per 30m². The variety in uses proposed also allows for a variety of socio-economic groups and skill levels. The location of employment uses in proximity to residential promotes a better quality of life.

The application site is located a 15minute cycle distance or 30 minute walking distance to Tullamore Train Station and town centre. There is an existing bus service which currently stops c.300m north of the site entrance providing a service to the town centre, train station, Tullamore Hospital and Retail Park to the east. The ethos behind the new neighbourhood promotes sustainable modes of transport, prioritising pedestrian and cyclists with more direct routes throughout the site and the improvement cyclist access to Tullamore Town Centre.

The predicted impact of the proposed development on employment and commuting patterns will be permanent moderate and overall positive.

4.6.4 Community Infrastructure Capacity

The proposed development will increase the population within the community by c. 942 persons. Figure 4.6 above illustrates the supply of community facilities available to the residents of Tullamore. The proposal includes the provision of a crèche which will support the new neighbourhood and provide a service that is currently not available in the immediate area. The provision of neighbourhood uses like retail/café/offices will serve local residents and enhance the facilities available in the area. A high percentage of the lands are allocated as public open space, including a civic square and improvement works to Clonminch Road to provide a safe and secure a pedestrian/cycle linkage. This will also benefit existing residents.

Using the National average, it is estimated that approximate 113no. of the children within the proposed development would be considered primary school age and 75no. would be considered secondary school age once complete (Census 2016 – An Age Profile of Ireland). As illustrated above (Table 4.2), current enrolments in primary schools in Tullamore within a 2.5km catchment amount to 1,546 students and secondary school enrolments amount to 1,842 students. In addition, according to the Department of Education and Skills online information sources, there are three additional 80m² classrooms being constructed at St. Joseph's National School, Arden View, Tullamore (no. 6 figure 9) and two additional 80m² classrooms at design stage for Scoil Eoin Phoil (no.7 figure 9). These two projects would cater for an additional 150no. primary school children based on a typical 80m² classroom plan. Improvement works are also on site at Sacred Heart School (no.3 figure 9), Tullamore to provide a new PE room and create an ASD unit.

[2] Child Care Act 1991 (Early Years Services) Regulations 2016

A school demand assessment has been prepared for the proposed development and submitted with the planning application under separate cover. It is considered that the potential school age population generated by the proposed development can be adequately absorbed by existing schools in Tullamore.

The overall impact of the proposed project is permanent moderate but positive in terms of the addition of community facilities and amenity space and will have slight to moderate impact on existing social infrastructure including schools.

4.6.5 Human Health

The proposed project will not result in any deterioration in human health to the existing population of Tullamore. This is predicted based on the findings of the Environmental Impact Assessments undertaken as part of this EIAR. The proposed development has been planned in keeping with Development Plan policy and is in keeping with National and Regional Guidelines, all of which have undergone Strategic Environmental Assessment. This is demonstrated in the Chapters of this EIAR which relate to the environmental factors of landscape, biodiversity, archaeology, cultural heritage, air quality and climate, noise and vibration, water, land and soils, material assets including traffic and transport.

It is submitted that the development of the subject lands, including the improvements to Clonminch Road will increase public safety. The location and design of the development will also encourage walking/cycling and public transport use thus further contributing to public health and well-being.

4.7 Mitigation Measures

Mitigation measures proposed during the construction phase will ensure that impacts relating to noise, dust and air quality are minimal. Further details are outlined in the relevant section of this EIAR. No mitigation is required for the operational stage with regard to population and human health.

4.8 Risk of Major Accidents and Disasters

4.8.1 Introduction

The amended 2014 Directive requires the expected significant adverse effects of a project on the environment deriving from the vulnerability of the project to risks of major accidents and/or disasters to be addressed.

The western boundary of the proposed development is 490metres from the eastern boundary of a lower tier COMAH site, William Grant & Sons Distillery which is subject to the provisions of the European Communities (Control of Major Accident Hazards Involving Dangerous Substances) Regulations, S.I. No. 209 of 2015. The 2015 COMAH Regulations place restrictions on land use planning on the types of development that can take place in the vicinity of COMAH establishments. A COMAH Land Use Planning assessment was completed by AWN Consulting Ltd. (report ref. MM/20/900P11565) for the proposed development in accordance with guidance published by the HSA (HSA, 2010) and is attached as Appendix 4.1.

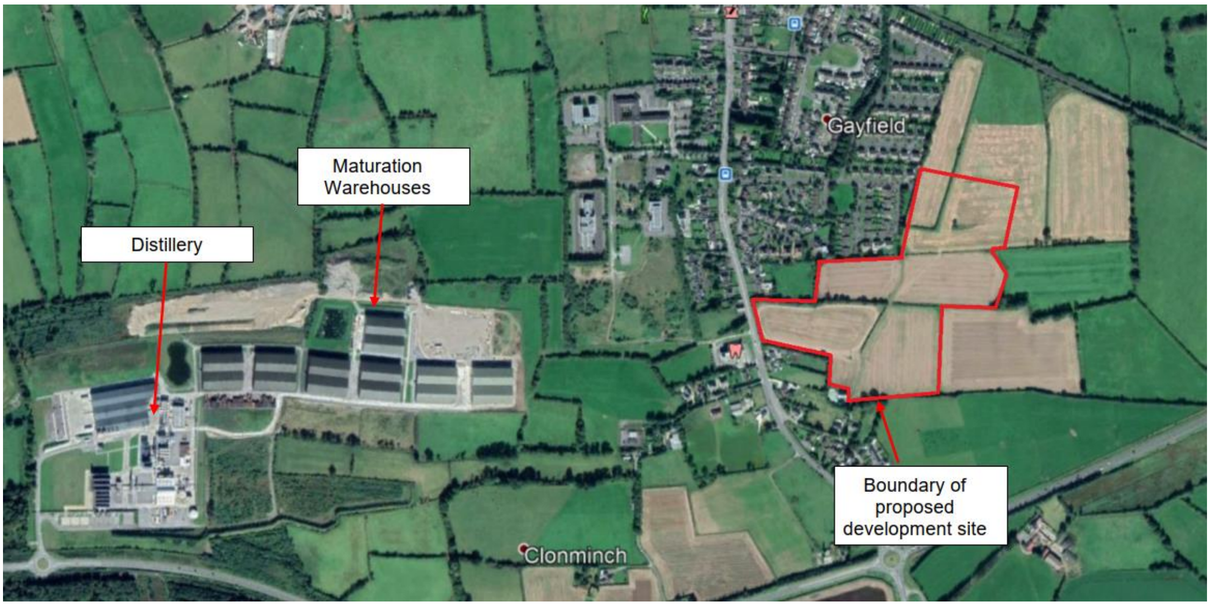


Figure -4.10 – Approximate application site boundary in relation to William Grant & Sons Distillery

4.8.2 Assessment Methodology

In order to assess potential health effects to people at the proposed development, a COMAH Land Use Planning assessment was completed by AWN Consulting Ltd. (report ref.MM/20/900P11565) in accordance with guidance published by the Health and Safety Authority (HSA) in the *Policy and Approach of the Health and Safety Authority to COMAH Risk-based Land-use Planning* (HSA, 2010). See Appendix 4.1. The assessment was completed in the following steps:

- Identify major accident scenarios with reference to the HAS Policy document (HSA, 2010);
- Consequence modelling of major accident scenarios;
- Assign frequencies to major accident scenarios with reference to frequency values outlined in the HSA's Policy Document (HSA, 2010)
- Assessment of individual risk and generation of individual risk contours.
- Where necessary, assessment of societal risk using societal risk indices.

Due to time between the initial preparation and lodgement of the previous planning application with EIAR under ABP-307832 and the subsequent redesign and preparation of the planning application that this EIAR has been prepared for, the HSA were contacted. HSA responded to there had been no change on site at William Grant and Sons. Therefore the LUP study did not require updating.

4.8.3 Assessment of Major Accident Hazards and Impacts on Human Health

The UK Health and Safety Laboratory (HSL) has investigated potential explosion hazards due to evaporating ethanol in whiskey distilleries (UK HSL, 2003). There appears to be a low probability of an explosion due to the ignition of an ethanol/air mixture. The evaporation rate of ethanol at 25 ºC is too low; the natural ventilation would almost certainly be able to dilute the gas cloud ethanol concentration down to well below its lower flammability limit. Therefore, a vapour cloud explosion scenario was ruled out for warehouses and outdoors. However, a confined VCE within the spirit receiving tank is a potential major accident scenario.

The following major accident scenarios assessed in this study are taken from the Notification submitted by William Grant & Sons Ltd. to the HSA and obtained by AWN in response to a request for information:

- Catastrophic rupture of Spirit Receiver Vessel leading to a Pool fire (bunded and unbunded)
- Confined Vapour Cloud Explosion (VCE) within spirit receiving tank
- Warehouse Fire

Risk contours for the proposed establishment corresponding to the boundaries of the inner, middle and outer risk-based land use planning zones are illustrated below

Figure 4. 11 - Individual Site Risk Contours

The following is concluded for Warehouse fire, Pool fire and explosion scenarios:

- Individual risk contours corresponding to the boundaries of the inner, middle and outer risk-based land use planning zones do not extend to the proposed development site.

In conclusion, the major accident scenarios discussed in this report have no expected impact on the proposed residential development.

4.84 Mitigating Measures

The consequences of the major accident scenarios; warehouse fire, pool fire (bunded and unbunded) and vapour cloud explosions were modelled using PHAST version 8.22 and TNO Effects Version 10.1 modelling software was used to model the risk-based land use planning contours for William Grant and Sons Distillery. It is concluded that the site individual risk contours do not extend to the proposed development and there is no expected impact on the proposed development from major accident scenarios.

Therefore no mitigation measures recommended in terms of site layout or restrictions on population density at the proposed development.

4.8.5 Residual Impacts/Monitoring

None predicted/required

4.8.6 Difficulties Encountered Compiling Information

No difficulties were encountered.

4.9 References

- Advice Notes on Current Practice in the Preparation of Environmental Impact Statements (EPA,2015)
- Central Statistics Office Website www.cso.ie
- Childcare Act 1991 (Early Years Services) Regulations, 2016
- Department of Education and Sciences website www.education.ie
- Draft Advice Notes for preparing Environmental Impact Statements (September, 2015).
- Tullamore Town and Environs Development Plan 2010-2016 (as varied and extended)
- Environmental Impact Assessment of Projects Guidance on the preparation of the Environmental Impact Assessment Report (Directive 2011/92/EU as amended by 2014/52/EU)' (EU, 2017) Central Statistics Office (CSO)
- Guidelines on the Information to be contained in Environmental Impact Assessment Reports (Draft, EPA,2017)
- Offaly County Development Plan 2014-2020
- National Planning Framework Ireland 2040 – Our Plan (Government of Ireland 2018)
- Pobal website www.pobal.ie
- Regional Spatial and Economic Strategy for the Eastern and Midland Regional Assembly (Government of Ireland 2019)

Appendix 4.1

Control of Major Accident Hazards (COMAH) Land Use Planning Assessment by AWN Consulting Limited

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PROPOSED DEVELOPMENT at TULLAMORE, CO. OFFALY COMAH BASED RISK ASSESSMENT

Technical Report Prepared For

Steinfort Investments Fund

Technical Report Prepared By

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Our Reference

MM/20/900P11565

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Document History

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Details	Written by	Approved by
Signature		
Name	Matthew Michie	Maeve Mckenna
Title	Consultant Chemist	Principal Risk Consultant
Date	22/05/20	25/05/2020

EXECUTIVE SUMMARY

AWN Consulting Ltd. was instructed by Steinfort Investments Fund to complete a COMAH Land Use Planning assessment for a proposed residential development in Tullamore, Co. Offaly.

The proposed development falls within the consultation distance of a whiskey distillery and warehouse maturation facility, William Grant & Sons. The distillery is a Lower Tier COMAH establishment and is subject to the provisions of the European Communities (Control of Major Accident Hazards Involving Dangerous Substances) Regulations, S.I. No. 209 of 2015. The 2015 COMAH Regulations place restrictions on land use planning on the types of development that can take place in the vicinity of COMAH establishments.

The Land Use Planning assessment was completed in accordance with guidance published by the HSA (HSA, 2010). The consequences of the major accident scenarios; warehouse fire, pool fire (bunded and unbunded) and vapour cloud explosions were modelled using PHAST version 8.22 and TNO Effects Version 10.1 modelling software.

Scenario	Consequences	Distance to proposed development (m)	Impacts at proposed development	Frequency
Warehouse Fire	Worst case 78 m to thermal radiation corresponding to the threshold of fatality (4.1 kW/m^2)	490	No expected impact	1E-04 per year
Warehouse Fire	Worst case CO_2 SLOD not reached	490	No expected impact	1E-04 per year
Bunded Pool Fire	Worst case 79.1 m to thermal radiation corresponding to the threshold of fatality (4.1 kW/m^2)	1,140	No expected impact	1E-03 per year
Unbunded Pool Fire	Worst case 103.1 m to thermal radiation corresponding to the threshold of fatality (4.1 kW/m^2)	1,090	No expected impact	1E-04 per year
VCE	Worst case 29 m to overpressure corresponding to 1 % fatality outdoors	1,140	No expected impact	1E-04 per year

TNO Riskcurves Version 10.1 modelling software was used to model the risk-based land use planning contours for William Grant & Sons distillery. It is concluded that the site individual risk contours do not extend to the proposed residential development.

In conclusion, the major accident scenarios discussed in this report have no expected impact on the proposed residential development.

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1.0 INTRODUCTION

AWN Consulting Ltd. was instructed by Steinfort Investments Fund to complete a COMAH Land Use Planning assessment for a proposed residential development in Tullamore, Co. Offaly.

The proposed development falls within the consultation distance of a whiskey distillery and warehouse facility, William Grant & Sons. The distillery is a Lower Tier COMAH establishment and is subject to the provisions of the European Communities (Control of Major Accident Hazards Involving Dangerous Substances) Regulations, S.I. No. 209 of 2015. The 2015 COMAH Regulations place restrictions on land use planning on the types of development that can take place in the vicinity of COMAH establishments. Therefore a COMAH LUP study is required to identify risk-based land use planning contours to establish the suitability of the development proposals.

This report includes a land use planning assessment in support of the proposed development and details the following:

- Description of development and surrounding environment;
- Background to risk assessment and land use planning context;
- Land Use Planning assessment methodology and criteria;
- Hazard Identification;
- Warehouse Fire Consequence Assessment;
- Ethanol Receiving tank Consequence Assessment;
- Frequency Analysis;
- Quantitative Risk Assessment of Major Accident Hazards;
- Conclusions.

2.0 DESCRIPTION OF DEVLOPMENT AND WILLIAM GRANT & SONS DISTILLERY

2.1 Description of Proposed Residential Development

The proposed residential development in Tullamore, Co. Offaly, comprises a mix of residential structures and is a Greenfield site bounded by the R443 to the west, residential properties to the north and south-west and undeveloped lands to the east and south-east. The western boundary of the proposed development is 490 m from the eastern boundary of a lower tier COMAH site, William Grant & Sons distillery.

The proposed development will consist of 351 residential units in a mix of 172 no. houses and 179 no. apartments (including 30 no. duplex), a crèche building (catering for 100 children) and a neighbourhood centre with uses such as pharmacy/shop, a medical centre and community centre measuring *circa* 2,800 m^2.

The location of the proposed development can be seen in Figure 2-1 and the layout of the proposed development in Figure 2-2.

2.2 Description of William Grant & Sons

William Grant & Sons distillery and maturation site, Tullamore, Co. Offaly, has been notified to the HSA as a 'Lower Tier' establishment under the 2015 COMAH Regulations. Information on the establishment was provided by the HSA in May 2020 in response to a request for information under the Access to Information on the Environment Regulations 2007 to 2014.

The location of the distillery can be seen in Figure 2-1 and the layout of the distillery can be seen in Figure 2-3.

2.2.1 Description of Distillery and Maturation Warehouses

Due to the presence of above threshold quantities of dangerous substances, the William Grant and Sons distillery at Tullamore is classified as a lower tier COMAH establishment. The operator has notified the HSA that there is the capacity to store 30,000 tonnes of cask strength whiskey (flammable liquid) at the distillery and maturation warehouses.

Figure 2-3 illustrates the layout of the establishment and the location of whiskey handling and storage areas (including tanks and maturation warehouses).

The largest storage vessel on site is a 100,000 litre capacity Spirit Receiver vessel which can store up to 78,000 litres of grain whiskey at 94.6 v/v% alcohol. The vessel is kept in a bund with volume 2450 m^3 with tertiary containment by means of a fire water retention pond. This vessel is located in the western area of the distillery, at location 21 shown on Figure 2-3.

There are two types of warehouse on site; the main storage warehouses and the smaller dunnage warehouses. The main storage warehouse are the main potential hazard to the surrounding area. The main warehouses have 2 no. of compartments with the dimensions 35 m x 70 m x 9 m. The compartments are separated by a 4 hour fire wall, the other walls and roof have a 1 hour fire protection. The warehouses are fitted with sprinkler systems which are designed to Factory Mutual (FM) standards. Each compartment can store up 27,550 x 190 L barrels of 65 % whiskey.

There are two stormwater attenuation and firefighting retention ponds with a combined capacity of 3,500 m^3. Warehouse units will drain to the firewater retention pond.

The major accident scenarios on-site are discussed in Section 5.0.

2.2.2 Hazardous Properties of Whiskey

Ethanol is a flammable liquid and ethanol vapour will form a flammable mixture with air at concentrations between approximately 3% and 19% by volume of the vapour in air. The flashpoint of ethanol solutions varies with the strength. Pure ethanol has a flashpoint of about 12°C, this rises to about 29°C at 40% alcohol by volume and to about 32°C at about 30% by volume. The Scotch Whiskey Association guidance document on managing flammable and explosive atmospheres (SWA, 2017 provides flash points of ethanol mixtures and indicates that cask strength whiskey (0 – 70% v/v) has a flash point of 23 – 25 °C.

The flashpoint of a liquid is the lowest temperature at which the liquid gives off enough vapour to form a flammable vapour-air mixture. If a liquid is at a temperature below its flashpoint, it is unlikely to form a flammable vapour-air mixture, unless it is released as a spray or mist. Liquids which have a flashpoint at, or below ambient temperature pose fire or explosion hazards without being heated.

The flammable, or explosion, limits of the vapour-air mixture define the range within which the mixture can be ignited and propagate flame through the mixture.

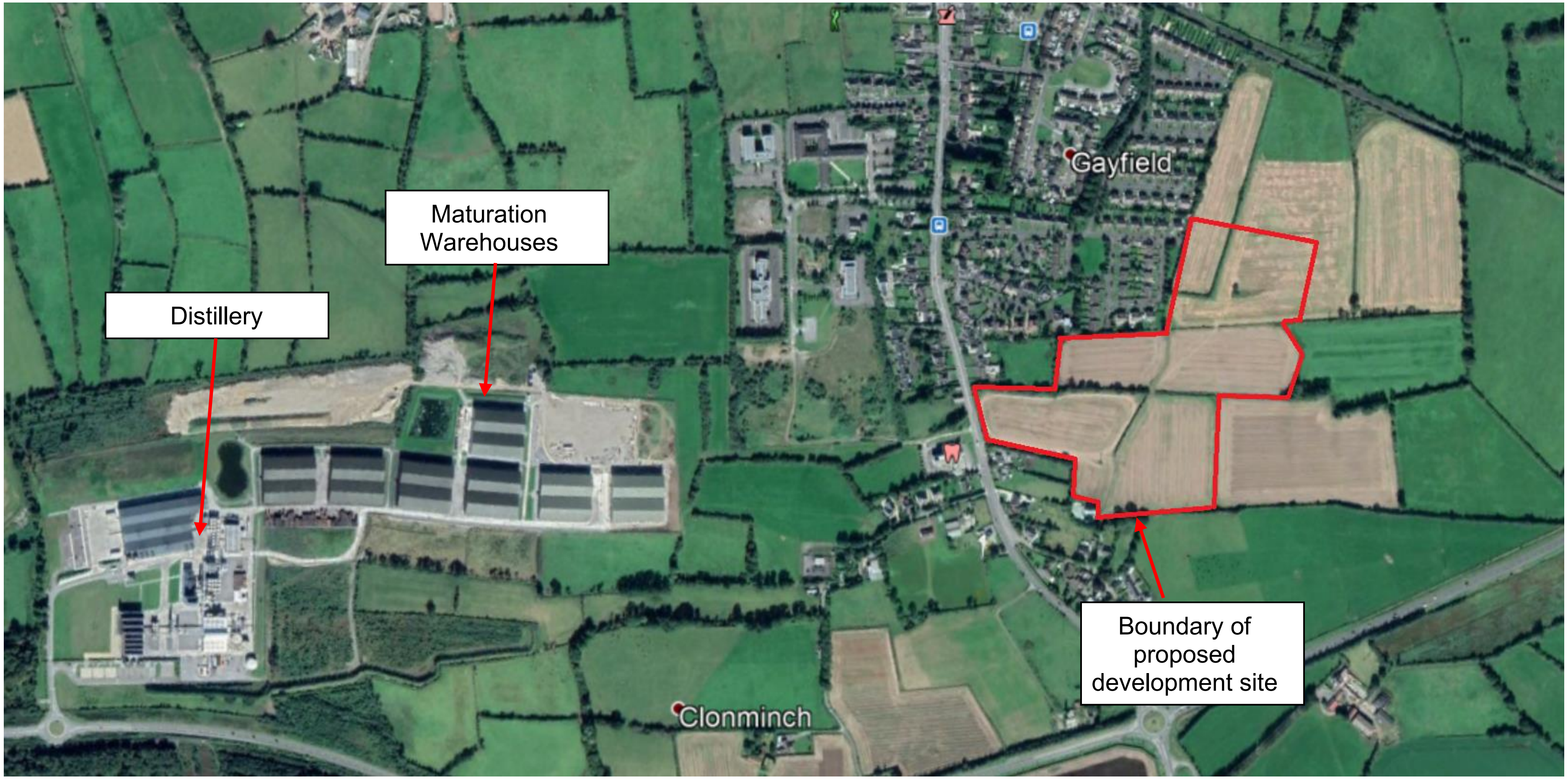


Figure 2-1 *Proposed residential development in red and William Grant & Sons distillery*

Figure 2-2 *Layout of proposed development*

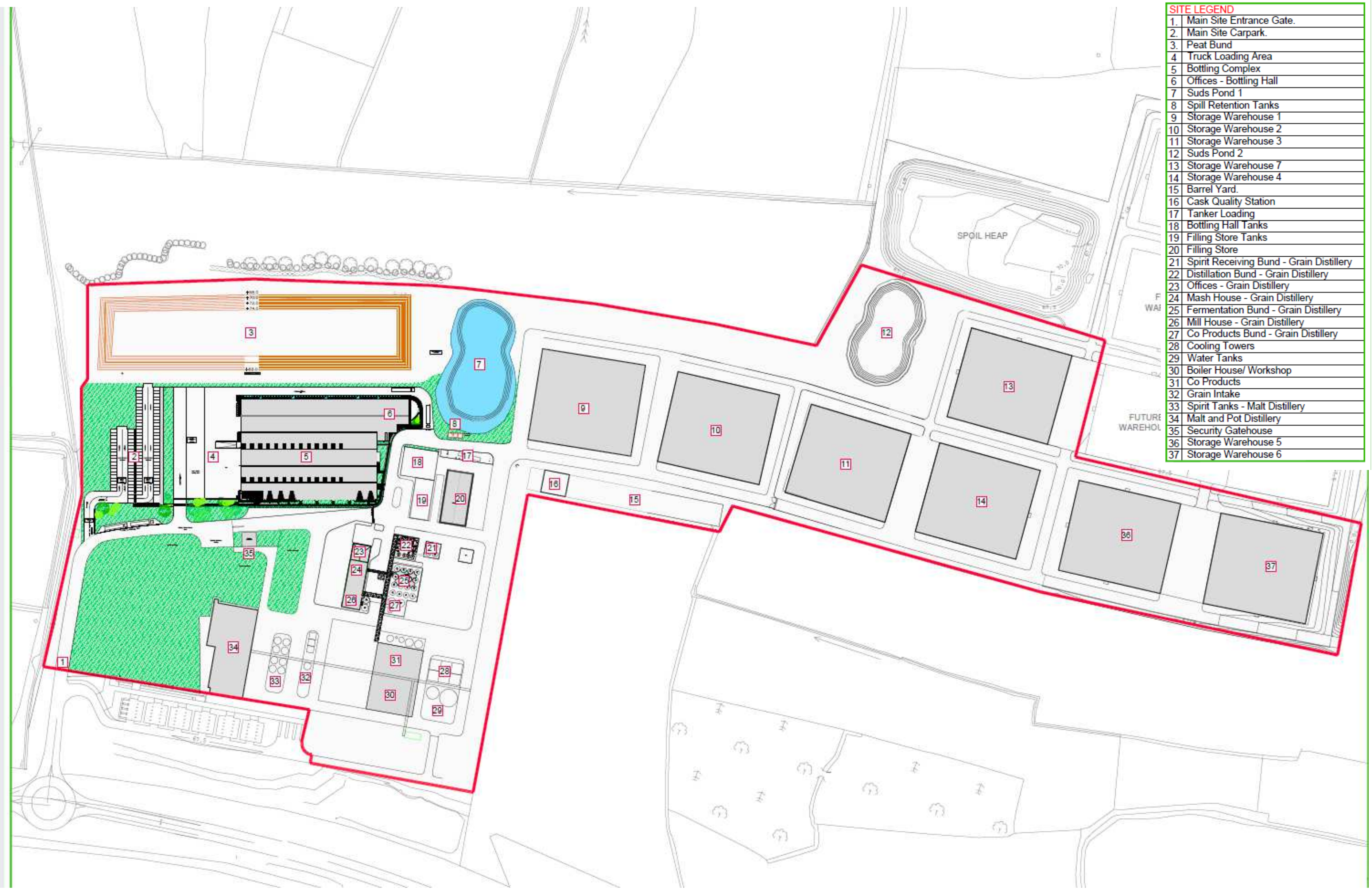


Figure 2-3 *Layout of William Grant & Sons Distillery*

3.0 BACKGROUND TO RISK ASSESSMENT AND LAND USE PLANNING

3.1 Risk Assessment – An Introduction

Trevor Kletz (Kletz, 1999) in his seminal work on the subject stated that the essential elements of quantitative risk assessment (QRA) are (i) how often is a Major Accident Hazard (MAH) likely to occur and (ii) Consequence Analysis – what is the impact of the incident:

Kletz also commented that another way of expressing this method of QRA is:

How often?

How big?

So what?

In QRA, the "how often?" question refers to the frequency of the major accident scenario and is answered with reference to historical industry data for similar incidents, or by using frequency analysis techniques.

Section 2 of the Health and Safety Authority (HSA) Land Use Planning Policy and Approach document (Introduction to Technical Aspects) describes the policy and approach as follows:

"The policy of the HSA is that a simplified application of a risk-based approach is the most appropriate for land use planning. The difficulties associated with the complexity of analysing many scenarios can be avoided by considering a small number of carefully chosen representative events, whose frequency has been estimated conservatively."

The frequency data for major accident scenarios identified in this assessment is based on these conservative frequency values.

The 'how big' element of the QRA was conducted using TNO Effects Version 10 modelling software.

The "so what" element is perhaps the most contentious issue associated with QRA, as one is essentially asking what an acceptable level of risk is, in this case risk of fatality, posed by a facility.

It is widely accepted that "no risk" scenarios do not exist. The occupier of a house with gas fired central heating is exposed to the risk posed by the presence of a natural gas supply in the house. Statistics from the UK Health and Safety Executive (UK HSE Risks associated with Gas Supply, 1993) show that the annual risk of death from gas supply events in the UK (risks include explosion, asphyxiation by fumes from poorly vented heaters, poisoning by gas leaks) is approximately 1.1 in a million. In other words, for every 10 million persons living in houses with a gas supply, 11 will die annually from events related to the supply.

Table 3-1 below presents the annual fatality rates, and the risk of fatality, for a number of activities (from CIRIA Report 152, 1995) in the UK.

Risk	Annual Fatality Rate (per 1,000, 000 people at risk)	Annual Risk of Fatality
Motorcycling	20,000	1 in 50
Smoking (all causes)	3000	1 in 333
Smoking (cancer)	1200	1 in 830
Fire fighting	800	1 in 1250
Farming	360	1 in 2778
Police work (non-clerical)	220	1 in 4545
Road accidents	100	1 in 10,000
Fires	28	1 in 35,700
Natural gas supply to house	1.1	1 in 909,090
Lightning strike	0.5	1 in 2,000,000

Table 3-1 Annual Fatality Rates for a Variety of Activities

Kletz has shown that the average industrial worker is exposed to a risk of accidental death of somewhere around 1 x 10^{-3} per year, for all situations (work, home, travel).

3.2 Land Use Planning and Risk Assessment

The Seveso III Directive (2012/18/EU) requires member states to ensure that the objectives of preventing major accidents and limiting the consequences of such accidents for human health and the environment are considered in land use planning policies through controls on the siting of new establishments, modifications to establishments and certain types of new developments in the vicinity of establishments. Under the 2015 COMAH Regulations, the Central Competent Authority (the Health and Safety Authority) provides land use planning advice to planning authorities.

A risk-based approach to land use planning near hazardous installations has been adopted by the HSA and is set out in the HSA's *Policy and Approach to COMAH Risk-based Land-use Planning (HSA, 2010)*. This approach involves delineating three zones for land use planning guidance purposes, based on the potential risk of fatality from major accident scenarios resulting in damaging levels of thermal radiation (e.g. from pool fires), overpressure (e.g. from vapour cloud explosions) and toxic gas concentrations (e.g. from an uncontrolled toxic gas release).

The HSA has defined the boundaries of the Inner, Middle and Outer Land Use Planning (LUP) zones as:

10E-05/year Risk of fatality for Inner Zone (Zone 1) boundary
10E-06/year Risk of fatality for Middle Zone (Zone 2) boundary
10E-07/year Risk of fatality for Outer Zone (Zone 3) boundary

The process for determining the distances to the boundaries of the inner, middle and outer zones for a Seveso/COMAH establishment is outlined as follows:

- Determine the consequences of major accident scenarios using the modelling methodologies described in the HSA LUP Policy/Approach Document (HSA, 2010);
- Determine the severity (probability of fatality) using the probit functions specified by the HSA;
- Determine the frequency of the accident (probability of event) using data specified

by the HSA;
- Determine the individual risk of fatality as follows:

Risk = Frequency x Severity ***(Equation 1)***

The HSA's 2010 Risk-Based LUP Policy/Approach document provides guidance on the type of development appropriate to the inner, middle and outer LUP zones. The advice for each zone is based on the UK Health and Safety Executive (HSE) Land Use Planning Methodology. The methodology sets four levels of sensitivity, with sensitivity increasing from 1 to 4, to describe the development types in the vicinity of a COMAH establishment.

The Sensitivity Levels used in Land Use Planning Methodology are based on a rationale which allows progressively more severe restrictions to be imposed as the sensitivity of the proposed development increases. The sensitivity levels are:

Level 1 Based on normal working population;
Level 2 Based on the general public – at home and involved in normal activities;
Level 3 Based on vulnerable members of the public (children, those with mobility difficulties or those unable to recognise physical danger);
Level 4 Large examples of Level 3 and large outdoor examples of Level 2 and Institutional Accommodation.

Table 3-2 details the matrix that is used by the HSA to advise on suitable development for technical LUP purposes:

Level of Sensitivity	Inner Zone (Zone 1)	Middle Zone (Zone 2)	Outer Zone (Zone 3)
Level 1	✓	✓	✓
Level 2	×	✓	✓
Level 3	×	×	✓
Level 4	×	×	×

Table 3-2 LUP Matrix

3.3 Individual Risk Criteria

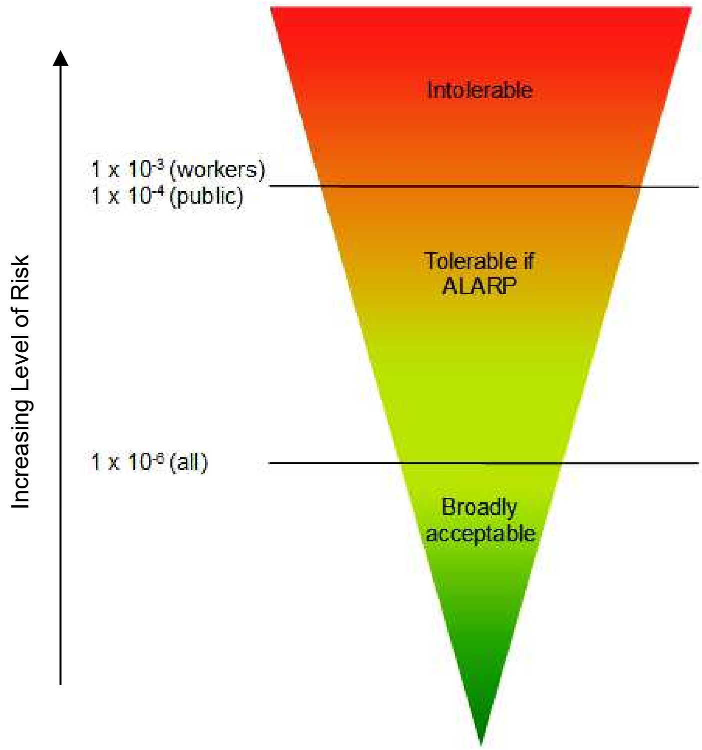
The HSA in Ireland has not specified tolerability criteria for individual risk of fatality, other than through restrictions to land use planning in the vicinity of Seveso establishments described in Section 3.2 herein.

In the UK, the following annual individual risk of fatality criteria apply to members of the public (Trbojevic, 2005):

10^{-4} Intolerable limit for members of the public;
10^{-5} Risk has to be reduced to the level As Low As Reasonably Practicable (ALARP);
3×10^{-6} LUP limit of acceptability;
10^{-6} Broadly acceptable level of risk
10^{-7} Negligible level of risk

In relation to tolerability criteria for individual risk of fatality to persons on-site, the HSA applies UK HSE criteria published in the guidance document Reducing Risks Protecting People (UK HSE, 2001).

The UK HSE generally uses a three-tier framework for risk tolerability:



The recommended upper risk of fatality bound for employees is set at 1 x 10^{-3}/year. The Chemical Industries Association (CIA, 2003) suggests that to allow only for the major hazard aspects of an employee's job, the upper bound should be reduced by a factor of 10 and thus be set at 1 x 10^{-4}/year.

The lower bound of risk – that at which no further effort needs to be applied to reduce risk - is generally considered to be about 1 x 10^{-6}/year.

4.0 LAND USE PLANNING ASSESSMENT METHODOLOGY AND CRITERIA

COMAH land use planning assessments are completed in accordance with risk-based approach set out in the HSA's *Policy and Approach to COMAH Risk-based Land-use Planning (HSA, 2010)*. LUP assessments are completed in the following steps:

- Identify major accident scenarios with reference to the HSA Policy document (HSA, 2010);
- Consequence modelling of major accident scenarios;
- Assign frequencies to major accident scenarios with reference to frequency values outlined in the HSA's Policy document (HSA, 2010);
- Assessment of individual risk and generation of individual risk contours;
- Where necessary, assessment of societal risk using societal risk indices.

4.1 Consequence Assessment

The warehouse units facilitate the storage and maturation of whiskey which is classified as a Flammable Liquid (Category C). A warehouse fire has the potential to generate hazardous levels of heat radiation as well as combustion products.

The spirit receiving tank stores 94.6 v/v% ethanol which is classified as a Flammable Liquid (Category 2). A pool fire has the potential to generate hazardous levels of heat radiation and a vapour cloud explosions has the potential to generate hazardous overpressures.

4.1.1 Physical Effects Modelling

The impacts of physical and health effects on workers and the general public outside of the establishment boundary were determined by modelling accident scenarios TNO Effects Version 10 and DNV PHAST Version 8.22 modelling software.

Thermal radiation exposure criteria and criteria for exposure to combustion products from a warehouse fire are based on the concept of a 'dangerous dose'.

A 'dangerous dose' is defined by the UK Health and Safety Executive as a dose where there is extreme distress to almost everyone, with a substantial proportion of affected persons requiring medical attention and some highly susceptible people might be killed (about 1% fatalities).

4.1.2 Thermal Radiation Criteria

Fire scenarios have the potential to create hazardous heat fluxes. Therefore, thermal radiation on exposed skin poses a risk of fatality.

Potential consequences of damaging radiant heat flux and direct flame impingement are categorised in Table 4-1 (HSA, 2010, CCPS, 2000, EI, 2007 and McGrattan et al, 2000).

Thermal Flux (kW/m^2)	Consequences
1 – 1.5	Sunburn
5 – 6	Personnel injured (burns) if they are wearing normal clothing and do not escape quickly
8 – 12	Fire escalation if long exposure and no protection

Thermal Flux (kW/m^2)	Consequences
32 – 37.5	Fire escalation if no protection (consider flame impingement)
31.5	US DHUD, limit value to which buildings can be exposed
37.5	Process equipment can be impacted, AIChE/CCPS
Up to 350	In flame. Steel structures can fail within several minutes if unprotected or not cooled.

Table 4-1 Heat Flux Consequences

In relation to persons indoors, the HSA have specified the thermal radiation consequence criteria (from an outdoor fire) detailed in Table 4-2 (HSA, 2010).

Thermal Flux (kW/m^2)	Consequences
> 25.6	Building conservatively assumed to catch fire quickly and so 100% fatality probability
12.7 – 25.6	People are assumed to escape outdoors, and so have a risk of fatality corresponding to that outdoors
< 12.7	People are assumed to be protected, so 0% fatality probability

Table 4-2 Heat Flux Consequences Indoors

Thermal Dose Unit (TDU) is used to measure exposure to thermal radiation. It is a function of intensity (power per unit area) and exposure time:

$$\text{Thermal Dose} = I^{1.33}\ t$$ (Equation 2)

where the Thermal Dose Units (TDUs) are $(kW/m^2)^{4/3}.s$, I is thermal radiation intensity (kW/m^2) and t is exposure duration (s).

The HSA recommends that the Eisenberg probit function (HSA, 2010) is used to determine probability of fatality to persons outdoors from thermal radiation as follows:

$$\text{Probit} = -14.9 + 2.56 \ln (I^{1.33}\ t)$$ (Equation 3)

I Thermal radiation intensity (kW/m^2)
t exposure duration (s)

Probit (Probability Unit) functions are used to convert the probability of an event occurring to percentage certainty that an event will occur. The probit variable is related to probability as follows (CCPS, 2000):

$$P = \frac{1}{\sqrt{2\pi}} \int_{-\infty}^{Y-5} \exp\left(-\frac{u^2}{2}\right) du$$ (Equation 4)

where P is the probability of percentage, Y is the probit variable, and u is an integration variable. The probit variable is normally distributed and has a mean value of 5 and a standard deviation of 1.

The Probit to percentage conversion equation is (CCPS, 2000):

$$P = 50\left[1 + \frac{Y-5}{|Y-5|} erf\left(\frac{|Y-5|}{\sqrt{2}}\right)\right] \qquad \text{(Equation 5)}$$

The relationship between Probit and percentage certainty is presented in Table 4-3 (CCPS, 2000).

%	0	1	2	3	4	5	6	7	8	9
0	—	2.67	2.95	3.12	3.25	3.36	3.45	3.52	3.59	3.66
10	3.72	3.77	3.82	3.87	3.92	3.96	4.01	4.05	4.08	4.12
20	4.16	4.19	4.23	4.26	4.29	4.33	4.36	4.39	4.42	4.45
30	4.48	4.50	4.53	4.56	4.59	4.61	4.64	4.67	4.69	4.72
40	4.75	4.77	4.80	4.82	4.85	4.87	4.90	4.92	4.95	4.97
50	5.00	5.03	5.05	5.08	5.10	5.13	5.15	5.18	5.20	5.23
60	5.25	5.28	5.31	5.33	5.36	5.39	5.41	5.44	5.47	5.50
70	5.52	5.55	5.58	5.61	5.64	5.67	5.71	5.74	5.77	5.81
80	5.84	5.88	5.92	5.95	5.99	6.04	6.08	6.13	6.18	6.23
90	6.28	6.34	6.41	6.48	6.55	6.64	6.75	6.88	7.05	7.33
%	**0.0**	**0.1**	**0.2**	**0.3**	**0.4**	**0.5**	**0.6**	**0.7**	**0.8**	**0.9**
99	7.33	7.37	7.41	7.46	7.51	7.58	7.65	7.75	7.88	8.09

Table 4-3 Conversion from Probits to Percentage

For long duration fires, such as pool fires, it is generally reasonable to assume an effective exposure duration of 75 seconds to take account of the time required to escape (HSA, 2010). It is noted that this is a conservative estimation of the time taken to escape and is used in consequence assessment as the maximum exposure duration for heat radiation.

With respect to exposure to thermal radiation outdoors, the Eisenberg probit relationship implies:

- 1% fatality – 966 TDUs (6.8 kW/m^2 for 75 s exposure duration) (Dangerous Dose)
- 10% fatality – 1452 TDUs (9.23 kW/m^2 for 75 s exposure duration)
- 50% fatality – 2387 TDUs (13.4 kW/m^2 for 75 s exposure duration)

4.1.3 Overpressure Criteria

Explosions scenarios can result in damaging overpressures, especially when flammable vapour/air mixtures are ignited in a congested area. Table 4-4 below describes blast damage for various overpressure levels (Mannan, 2012).

Side-on Overpressure (mbar)	Description of Damage
1.5	Annoying noise
2	Occasional breaking of large window panes already under strain
3	Loud noise; sonic boom glass failure
7	Breakage of small windows under strain
10	Threshold for glass breakage
20	“Safe distance”, probability of 0.95 of no serious damage beyond this value; some damage to house ceilings; 10% window glass broken
30	Limited minor structural damage
35 – 70	Large and small windows usually shattered; occasional damage to window frames
>35	Damage level for “Light Damage”
50	Minor damage to house structures
80	Partial demolition of houses, made uninhabitable
70 - 150	Corrugated asbestos shattered. Corrugated steel or aluminium panels fastenings fail, followed by buckling; wood panel (standard housing) fastenings fail; panels blown in
100	Steel frame of clad building slightly distorted
150	Partial collapse of walls and roofs of houses
150-200	Concrete or cinderblock walls, not reinforced, shattered
>170	Damage level for “Moderate Damage”
180	Lower limit of serious structural damage 50% destruction of brickwork of houses
200	Heavy machines in industrial buildings suffered little damage; steel frame building distorted and pulled away from foundations
200 – 280	Frameless, self-framing steel panel building demolished; rupture of oil storage tanks
300	Cladding of light industrial buildings ruptured
350	Wooden utility poles snapped; tall hydraulic press in building slightly damaged
350 – 500	Nearly complete destruction of houses
>350	Damage level for “Severe Damage”
500	Loaded tank car overturned
500 – 550	Unreinforced brick panels, 25 - 35 cm thick, fail by shearing or flexure
600	Loaded train boxcars completely demolished
700	Probable total destruction of buildings; heavy machine tools moved and badly damaged

Table 4-4 *Blast Damage*

There are a number of modes of explosion injury including eardrum rupture, lung haemorrhage, whole body displacement injury, missile injury, burns and toxic exposure. Table 4-5 describes injury criteria from blast overpressure including probability of eardrum rupture and probability of fatality due to lung haemorrhage.

Probability of Eardrum Rupture (%)	Peak overpressure (mbar)
1 (threshold)	165
10	194
50	435
90	840
Probability of Fatality due to Lung Haemorrhage (%)	**Peak overpressure (mbar)**
1 (threshold)	1000
10	1200
50	1400
90	1750

Table 4-5 *Injury Criteria from Explosion Overpressure*

The HSA recommends that the Hurst, Nussey and Pape probit function (HSA, 2010) is used to determine probability of fatality to persons outdoors from overpressure as follows:

$$Probit = 1.47 + 1.35 \ln P$$

P Blast overpressure (psi)

The Hurst, Nussey and Pape probit relationship implies:

- 1% fatality – 168 mbar (Dangerous Dose)
- 10% fatality – 365 mbar
- 50% fatality – 942 mbar

The HSA uses relationships published by the Chemical Industries Association (CIA) to determine the probability of fatality for building occupants exposed to blast overpressure. The CIA has developed relationships for 4 categories of buildings (CIA, 2010):

- Category 1: hardened structure building (special construction, no windows);
- Category 2: typical office block (four storey, concrete frame and roof, brick block wall panels);
- Category 3: typical domestic dwelling (two storey, brick walls, timber floors); and
- Category 4: 'portacabin' type timber construction, single storey.

The CIA relationships imply the overpressure levels corresponding to probabilities of fatality of 1%, 10% and 50% detailed in Table 4-6 below.

Probability of fatality	Overpressure Level, mbar			
	Category 1	Category 2	Category 3	Category 4
1% fatality (dangerous dose)	435	100	50	50
10% fatality	519	183	139	115
50% fatality	590	284	300	242

Table 4-6 *Blast Overpressure Consequences Indoors*

For the purposes of this assessment, it is assumed that the vulnerability of building occupants at the proposed development to side-on overpressure are represented by Category 2 and Category 3 type structures.

4.1.4 Warehouse Fire Combustion Products

The HSA Policy/Approach document states that the main concern in terms of off-site risk and land use planning is the risk associated with a large warehouse fire, involving the release of hazardous materials from several containers. This could lead to a plume of toxic smoke which could disperse off site.

The TNO Effects combustion and toxic combustion products is based on the method described in the Green Book CPR 16E (TNO, 1992).

The Effects model calculates the rate at which the following combustion products are formed:

- NO_2 formation rate (kg/s)
- SO_2 formation rate (kg/s)
- HCl formation rate (kg/s)
- HBr formation rate (kg/s)
- HF formation rate (kg/s)
- CO_2 formation rate (kg/s)
- H_2O formation rate (kg/s)

Alcohol has the chemical formula C_2H_5OH. Only CO_2 and H_2O will form in the event of a warehouse fire. The other toxic combustion products listed above will not form.

For the purposes of the assessment, high wind speed conditions are considered (> 10 m/s), which generally occur for less than 10% of the time.

Toxic Dose

Exposure to toxic combustion products is assessed by determining the toxic dose received by a sensitive receptor.

The toxicity expressed by a given substance in the air is influenced by two factors, the concentration in the air (c) and the duration of exposure (t). A functional relationship between c and t can be developed, such that the end product of this relationship is a constant:

$$f(C,t) = \text{constant} \qquad \text{(Equation 6)}$$

This constant is known as the Toxic Load or Toxic Dose and is calculated as follows:

$$\textit{Toxic Load} = C^n.t \qquad \text{(Equation 7)}$$

The UK Health and Safety Executive have set out Specified Level of Toxicity (SLOT) Dangerous Toxic Load (DTL) values. The UK HSE has defined land use planning SLOT as:

- Severe distress to almost everyone in the area;
- Substantial fraction of exposed population requiring medical attention;
- Some people seriously injured, requiring prolonged treatment;
- Highly susceptible people possibly being killed.

These criteria are fairly broad in scope, reflecting the fact that:

- There is likely to be considerable variability in the responses of different individuals affected by a major accident;
- There may be pockets of high and low concentrations of a toxic substance in the toxic cloud release, so that not everyone will get exactly the same degree of exposure; and
- The available toxicity data are not usually adequate for predicting precise dose-response effects.

The SLOT DTL value approximately equates to the toxic load which would give rise to 1% fatality. The UK HSE has also assigned Significant Likelihood of Death (SLOD) Dangerous Toxic Load (DTL) values to toxic substances. The SLOD DTL value equates to the toxic load which would give rise to a likely fatality of 50%.

4.1.5 Modelling Parameters

4.1.5.1 Weather Conditions

Weather conditions at the time of a major accident have a significant impact on the consequences of the event. Typically, high wind speeds increase the impact of fires, particularly pool fires, while the associated turbulence dilutes vapour clouds, reducing the impact of toxic and flammable gas releases.

Atmospheric Stability Class and Wind Speed

Atmospheric stability describes the amount of turbulence in the atmosphere. The stability depends on the windspeed, time of day, and other conditions. Atmospheric stability classes are described in Table 4-7 (DNV, PHAST supporting documentation).

Wind speed (m/s)	Day: Solar Radiation			Night: Cloud Cover		
	Strong	Moderate	Slight	Thin, <40%	Moderate	Overcast, >80%
2	A	A-B	B	-	-	D
2 – 3	A-B	B	C	E	F	D
3 – 5	B	B-C	C	D	E	D
5 – 6	C	C-D	D	D	D	D
6	C	D	D	D	D	D

Table 4-7 Atmospheric Stability Class

Stability classes are described as follows:

- A very unstable (sunny with light winds)
- B unstable (moderately sunny, stronger winds than class A)
- C slightly unstable – very windy/sunny or overcast/light wind
- D neutral – little sun and high wind or overcast night
- E stable – moderately stable – less overcast and windy than class D
- F very stable – night with moderate clouds and light/moderate winds

The following Pasquill stability/wind speed pairs are specified by the HSA in Ireland for consequence modelling:

- Average weather conditions are represented by stability category D and a wind speed of 5 m/s, i.e. Category D5;

- Worst case conditions for toxic dispersion are represented by stability category F and a wind speed of 2 m/s, i.e. Category F2;
- A wind speed of 10 m/s represents the worst-case condition for fire scenarios, with stability category D, i.e. Category D10.

Wind Direction and Ambient Temperature

The nearest synoptic metrological station to the Tullamore site for which long term meteorological data is available is at Dublin Airport.

Figure 4-1 illustrates a wind rose for Dublin Airport (1989-2018). It can be seen that the prevailing wind direction is from the south west (240 °).

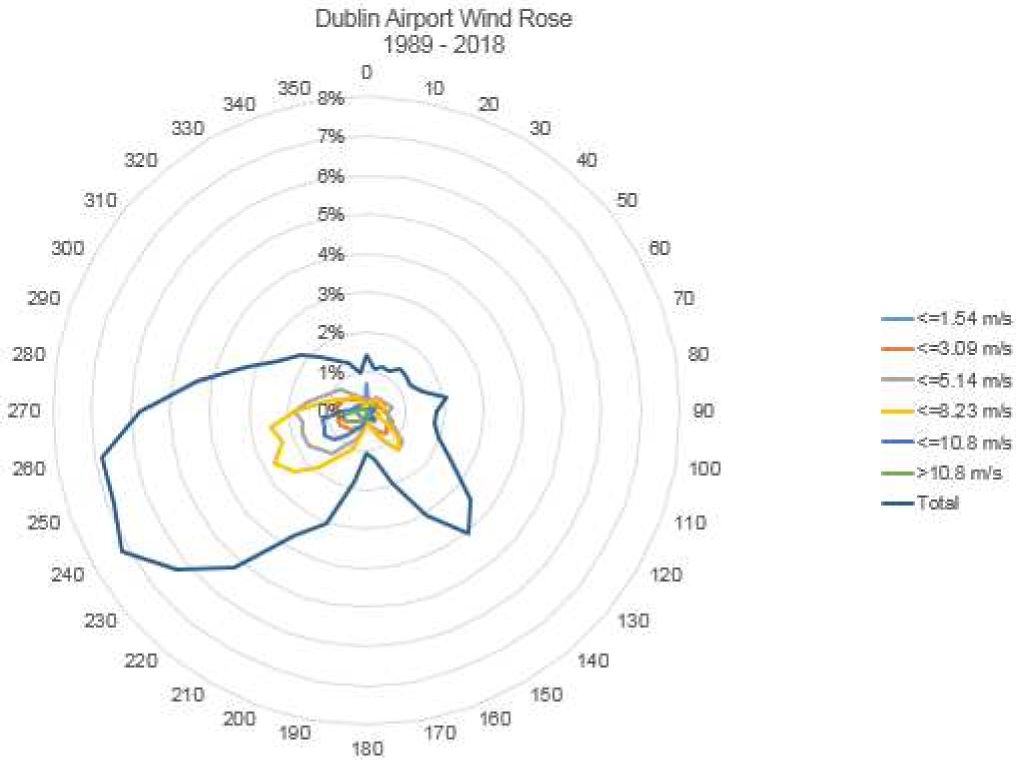


Figure 4-1 Wind Rose Dublin Airport 1989-2018

Ambient Temperature

The ambient and surface temperature conditions significantly impact the results of the consequence modelling. Typically, atmospheric temperatures in the Dublin area range from -12.2°C to 28.7°C through the year (Dublin Airport 1981 – 2010 averages, www.met.ie).

According to the weather data recorded between 1981 and 2010 at Dublin Airport, the average atmospheric temperature observed is 9.8°C. Therefore, an ambient temperature of 10°C has been selected to represent typical temperature conditions at the site.

Ambient Humidity

Weather data for Dublin Airport, monthly and annual mean and extreme values datasheet supplied by Met Éireann, indicates a mean morning (09:00 UTC) relative humidity of 83% and a mean afternoon (15:00 UTC) humidity of 73.3%. Therefore, for this assessment, a representative ambient humidity of 80% has been assumed.

4.1.5.2 Surface Roughness

Surface roughness describes the roughness of the surface over which the cloud is dispersing. Typical values for the surface roughness are as follows (DNV, PHAST supporting documentation):

Roughness length	Description
0.0002 m	Open water, at least 5 km
0.005 m	Mud flats, snow, no vegetation
0.03 m	Open flat terrain, grass, few isolated objects
0.1 m	Low crops, occasional large obstacles, x/h > 20
0.25 m	High crops, scattered large objects, 15 < x/h < 20
0.5 m	Parkland, bushes, numerous obstacles, x/h < 15
1.0 m	Regular large obstacles coverage (suburb, forest)
3.0 m	City centre with high- and low-rise buildings

Table 4-8 Surface Roughness

The terrain within the vicinity of Tullamore contains is mainly agricultural with residential developments along roadways which constitute occasional large obstacles. Therefore, a surface roughness length of 0.1 m is selected for the study.

4.2 Individual Risk Assessment Methodology

TNO RiskCurves Version 10.1 modelling software is used in this assessment to calculate individual risk of fatality contours and risk-based land use planning zones associated with major accident scenarios.

5.0 IDENTIFICATION OF MAJOR ACCIDENT SCENARIOS

The main hazards associated with the storage and handling of flammable liquids, such as potable alcohol are fire and explosion involving the vapour associated with it. Fires and explosions can occur when vapour or gas is released and comes into contact with an ignition source.

The UK Health and Safety Laboratory (HSL) has investigated potential explosion hazards due to evaporating ethanol in whiskey distilleries (UK HSL, 2003). There appears to be a low probability of an explosion due to the ignition of an ethanol/air mixture. The evaporation rate of ethanol at 25 ºC is too low; the natural ventilation would almost certainly be able to dilute the gas cloud ethanol concentration down to well below its lower flammability limit. Therefore, a vapour cloud explosion scenario was ruled out for warehouses and outdoors. However, a confined VCE within the spirit receiving tank is a potential major accident scenario.

The following major accident scenarios assessed in this study are taken from the Notification submitted by William Grant & Sons Ltd. to the HSA and obtained by AWN in response to a request for information:

- Catastrophic rupture of Spirit Receiver Vessel leading to a Pool fire (bunded and unbunded)
- Confined Vapour Cloud Explosion (VCE) within spirit receiving tank
- Warehouse Fire

6.0 WAREHOUSE FIRE ASSESSMENT

6.1 Warehouse Fire Model Inputs

As described in Section 2.2 above, whiskey is stored on site. There are 7 warehouses on site, each with 2 compartments, separated by a 4 hour fire wall. The worst case scenario would be a warehouse fire in warehouse 6 (Figure 2-3) as this is closest to the proposed development.

The warehouse fire model inputs are detailed in Table 6-1.The pool size is taken to be equal to the floor area of each unit

Parameter	Units	Value	Description
Substance	-	Ethanol	Conservative approach – ethanol used to represent whiskey
Pool size	m^2	2450	Floor area of compartment
Mass of product in compartment	tonne	4130	Based on 190 litres per cask and a specific gravity of 0.93. 27,550 Casks
Mass of fuel involved	tonne	4130	Entire inventory of warehouse compartment (Worst case assumption)
Effect height	m	1.5	Standard effect height for receivers
Surface Emissive Power	kW/m^2	52	From HSA Land Use Planning Guidance for Class 1 hydrocarbons
Wind speed	m/s	5 and 10	From HSA Land Use Planning Guidance
Wind direction	deg	240	From wind rose for Dublin Airport synoptic meteorological station, the nearest weather station for which long term average weather data is available

Table 6-1 Warehouse Fire Model Inputs

6.2 Heat Radiation Results

The warehouse fire scenario is modelled as a pool fire. A pool fire is a turbulent diffusion fire burning above a horizontal pool of vaporising fuel where the fuel has zero or low initial momentum. The characteristics depend on the pool diameter as the liquid burning rate increases with diameter until it reaches a large diameter and the burning rate is then fixed. Heat radiated from the fire behaves similarly, *i.e.* the greater the pool size the greater the level of heat generated. The quantity of fuel contributes mainly to the duration of the pool fire.

Pool fire model outputs are summarised in Table 6-2

Parameter	Units	Value
Combustion rate	kg/s	49
Duration of fire	min	1404.4
Surface emissive power	kW/m^2	52

Table 6-2 Pool Fire Model Outputs

Figure 6-1 illustrates the Thermal radiation *vs* Distance for a Warehouse fire and Figure 6-2 illustrates the Probability of Fatality Outdoors *vs* Distance for a wind speed of 5 m/s.

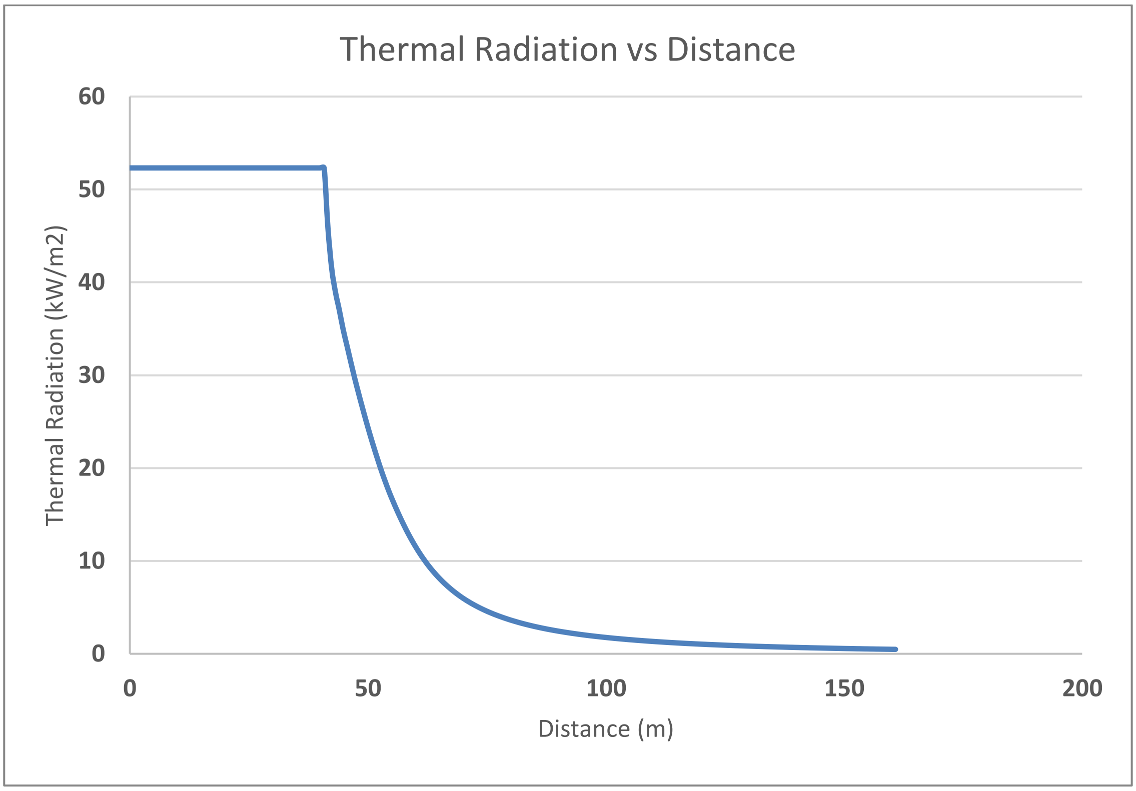


Figure 6-1 *Warehouse Fire: Thermal radiation vs Distance*

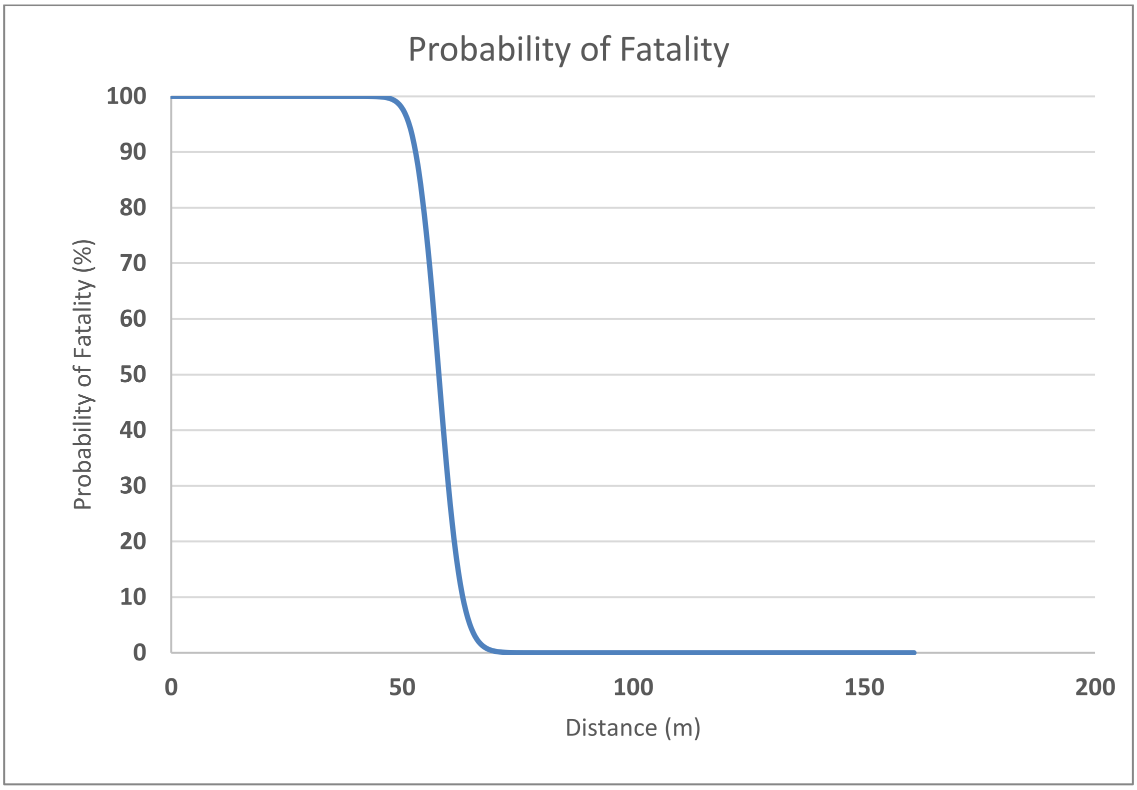


Figure 6-2 *Warehouse Fire: Probability of Fatality Outdoors vs Distance*

Distances to endpoint thermal radiation levels are summarised in Table 6-3.

Parameter	Units	Distance (m)	
		5 m/s	10 m/s
Threshold of fatality (4.1 kW/m^2)	m	78	72
1% probability of fatality outdoors (6.8 kW/m^2)	m	70	65
10% probability of fatality outdoors (9.23 kW/m^2)	m	65	61
50% probability of fatality outdoors (13.4 kW/m^2)	m	60	58

Table 6-3 Distances to Thermal Radiation Endpoints

Thermal radiation contours for Warehouse 6, the warehouse closest to the proposed development, are illustrated in Figure 6-3. Thermal radiation contours corresponding to 1% fatality outdoors (6.8 kW/m^2), 10% fatality outdoors (9.23 kW/m^2) and 50% fatality outdoors (13.4 kW/m^2).

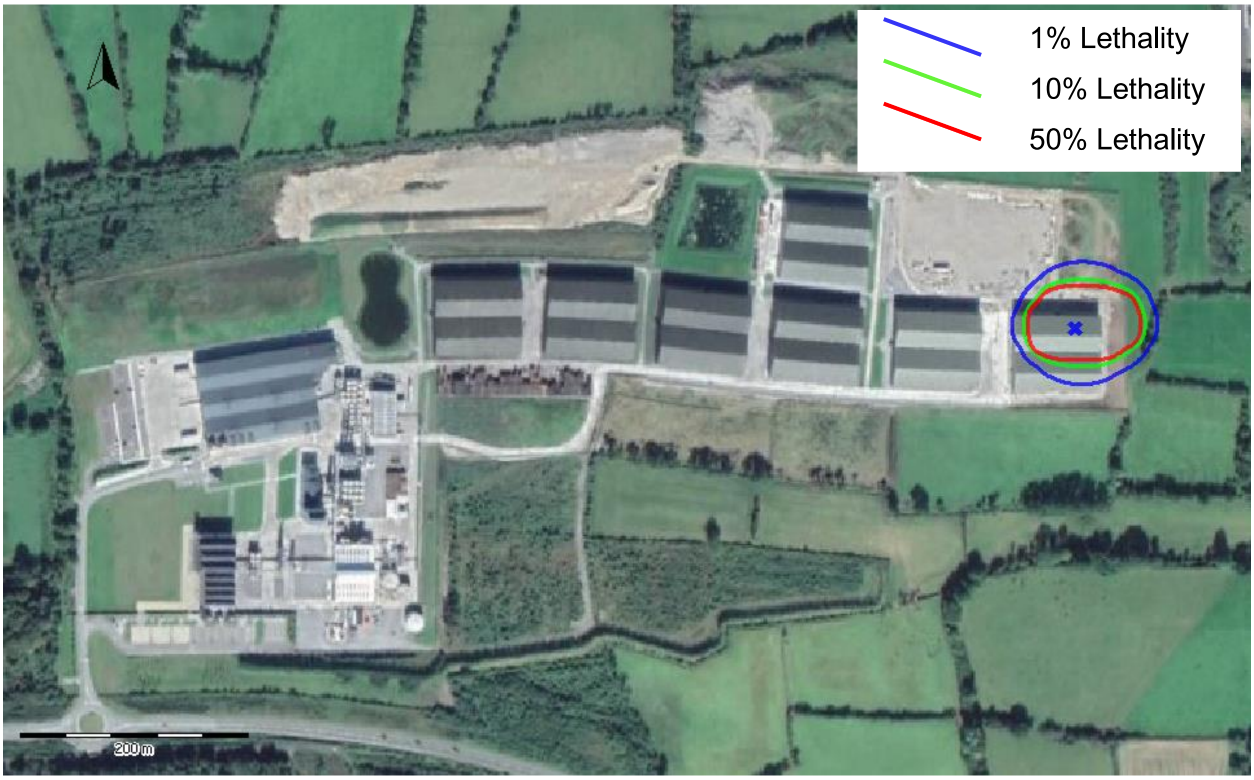


Figure 6-3 Consequence Contours for 1%, 10% and 50% Mortality Outdoors at Warehouse 6a

The following is concluded:

- The proposed development is 490 m from warehouse 6.
- The threshold of fatality for thermal radiation (4.1 kW/m^2) extends 77 m from warehouse 6; therefore, there are no expected impacts at the proposed residential development.

6.3 Combustion Products

As described in Section 4.1.4 the TNO Effects (Version 10.1.9) combustion products model was used to calculate the release rate of combustion products from a warehouse fire involving whiskey. The model inputs are based on the inventory and dimensions of each warehouse. As detailed in Table 6-1 the inventory within each unit is 4130 tonnes of whiskey product. The combustion rate of whiskey and maximum fire duration are given in Table 6-2.

The model predicts a release rate of carbon dioxide (CO_2) of 18.74 kg/s. No other toxic combustion products are predicted to be generated.

The carbon dioxide release rate predicted by the combustion products model provides the input to the dispersion model. As per HSA advice (HSA, 2010) dispersion modelling is completed for the D10 Pasquill stability-wind speed category for the warehouse fire scenario. Other atmospheric parameters are as detailed in Section 4.1.55. Dispersion results for CO_2, are presented on Figure 5.6.

Figure 6-4 shows smoke and combustion products are released at roof height (9 m) and dispersion results are presented for a receptor height of 1.5 m.

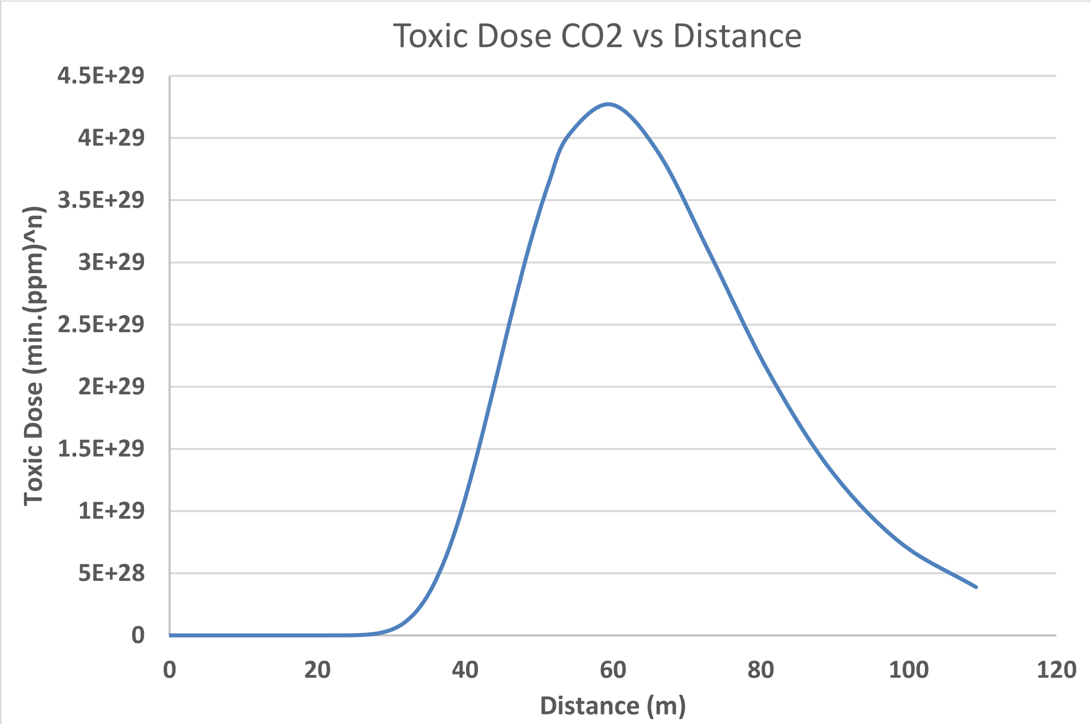


Figure 6-4 Warehouse Fire Combustion Products: CO_2 Dose vs. Distance

The toxic dose endpoints of interest are detailed in Table 6-4.

Combustion Product	Toxic Endpoint	Units	n	Value	Distance
CO_2	SLOT DTL	ppm^n.min	8	1.50E+40	Not reached
CO_2	SLOD DTL	ppm^n.min	8	1.50E+41	Not reached

Table 6-4 Warehouse Fire Release Rate of Toxic Combustion Products

It is concluded that the maximum dose of carbon dioxide reached is 5.17E23 ppm^8.min. The SLOT DTL for CO_2 is 1.5E+40 ppm^8.min. It is concluded that in the event of a warehouse fire, dose levels corresponding to the SLOT DTL (and also the SLOD DTL) are not reached. It is concluded that no toxic effects are expected to arise as a result of a warehouse fire at the existing units.

7.0 Ethanol Receiving Tank

7.1 Vapour Cloud Explosion

A vapour cloud explosion of ethanol confined within the receiving tank was modelled. The tank has a volume of 100 m^3. The flammable mass within the tank was calculated to be 11.82 kg using a stoichiometric model, assuming the tank was at 10 % capacity.

The TNO Multi-Energy VCE model inputs are as follows:

- Flammable mass: 11.82 kg
- Confined fraction: 1
- Curve number: 7 (strong deflagration, conservative assumption)

7.1.1 VCE Consequences

The peak overpressure with distance results are illustrated as follows:

- Figure 7-1 shows Overpressure *vs* Distance

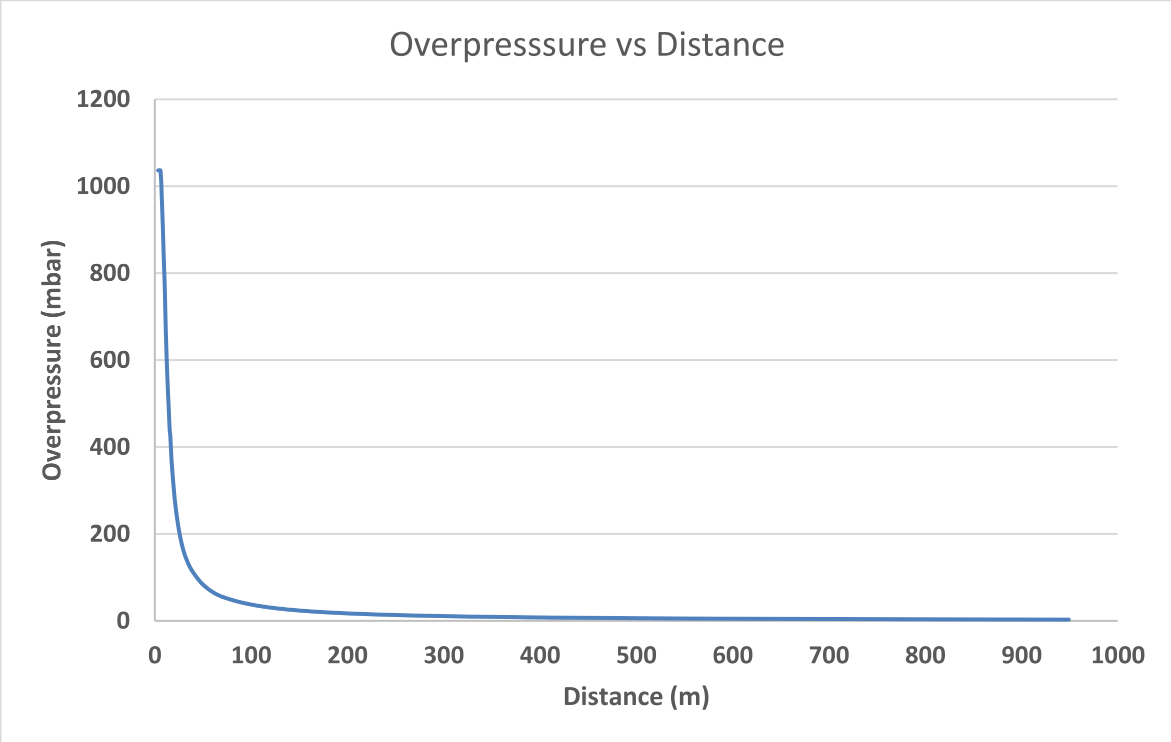


Figure 7-1 Receiving tank VCE: Peak Overpressure vs. Distance

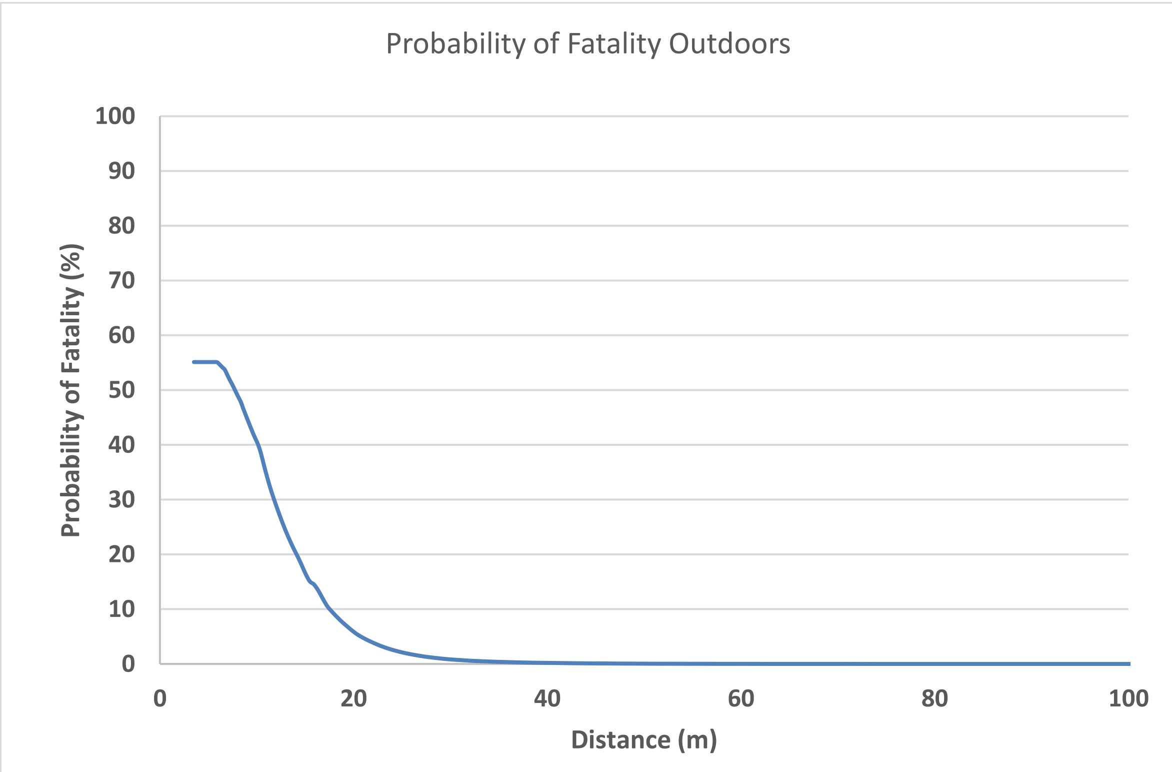


Figure 7-2 *Receiving tank VCE: Probability of Fatality Outdoors vs Distance*

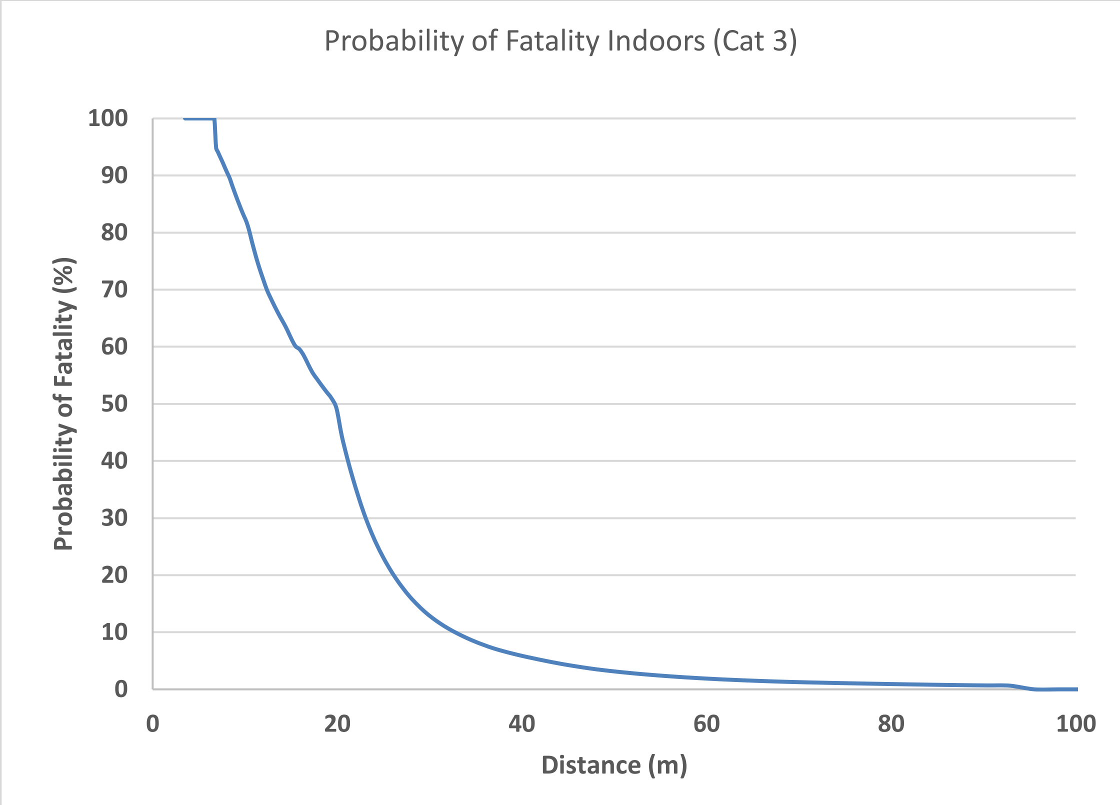


Figure 7-3 *Receiving tank VCE: Probability of Fatality Indoors (Cat 3) vs Distance*

Table 7.1 below details the distance to overpressure levels relating to damage and fatality outdoor and indoor (category 3 type buildings).

Peak overpressure (mbar)	Consequences	Distance (m)
20	Safe distance - probability of 0.95 of no serious damage beyond this value; some damage to house ceilings; 10% window glass broken	175
35	Light damage	107
168	1% mortality outdoors	29
365	10% mortality outdoors	18
942	50% mortality outdoors	8
50	1% mortality Indoors (Cat 3 type building (Residential))	77
100	10% mortality outdoors (Cat 3 type building (Residential))	44

Table 7-1 *Receiving tank VCE: Overpressure Results*

Figure 7-4 and Figure 7-5 show the mortality contours for a VCE in the Receiving Tank for outdoor and indoor (Category 3 type buildings) respectively.

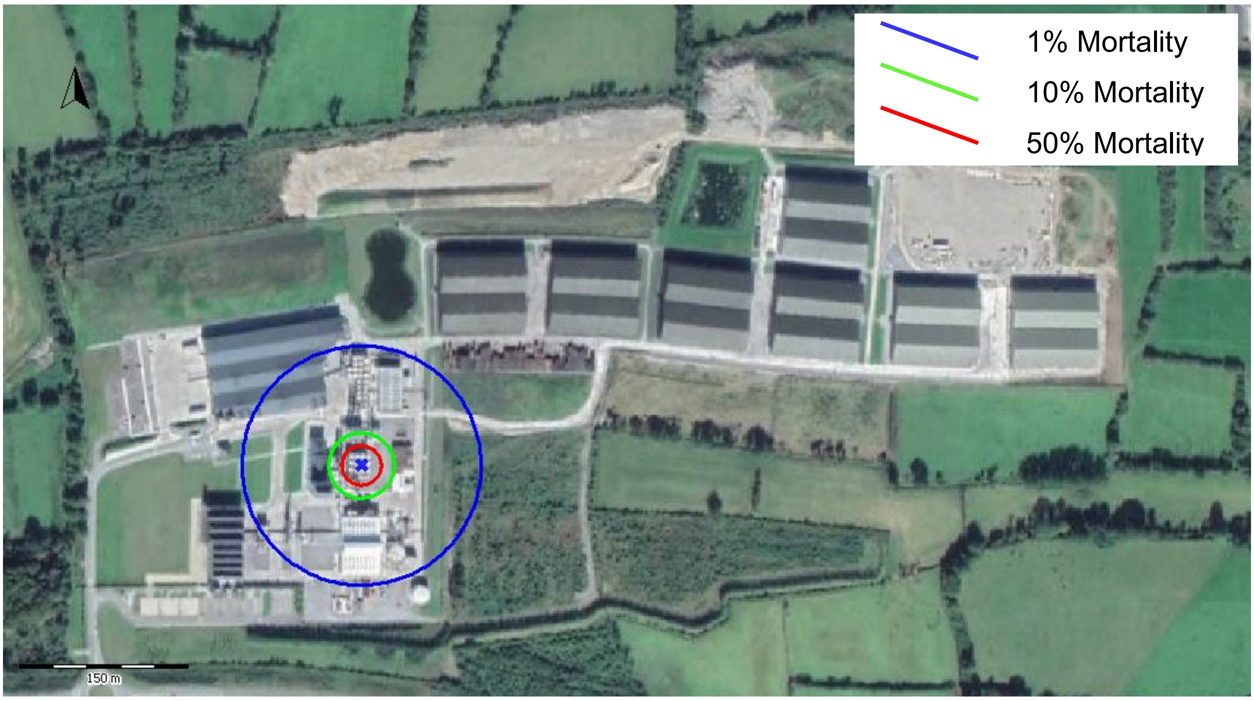


Figure 7-4 Ethanol VCE: Outdoor Mortality contours

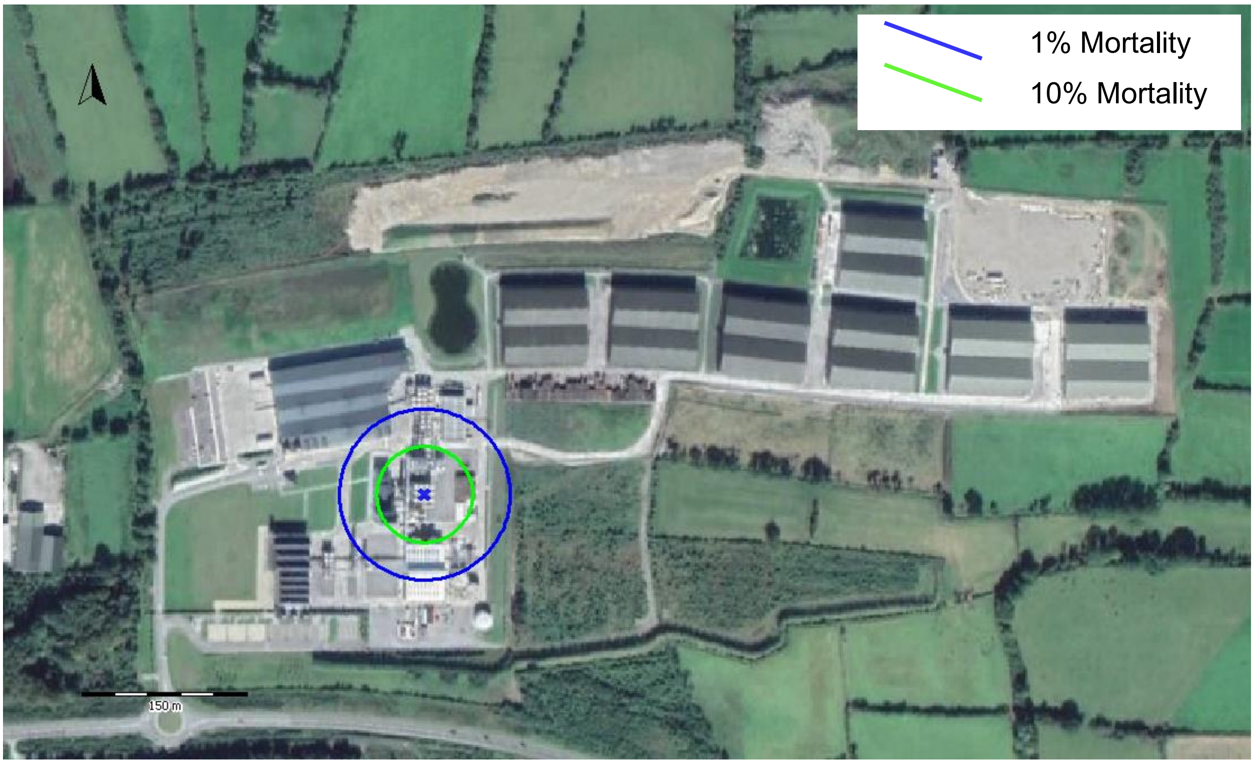


Figure 7-5 *Ethanol VCE: Indoor mortality contours Category 3 – residential developments*

The following is concluded:

- The proposed development is 1,140 m from the spirit receiving tank
- The distance to overpressure levels corresponding to 1% fatality outdoors (168mbar) extends 29 m from the spirit receiving tank

- Distance to overpressure levels corresponding to 1 % fatality indoor (50 mbar) extends 77 m from the spirit receiving tank
- There are no expected impacts (damage or mortality) from a VCE at the proposed development

7.2 Pool Fire

7.2.1 Bunded Pool Fire

In the event of a major spill of ethanol from the Receiving Tank, a pool of ethanol would form within the bund. Should this material ignite, a pool fire would result with thermal radiation consequences.

The bund area is calculated to be 2450 m^2. Model inputs are described in Table 7-2.

Parameter	Units	Value	Description
Substance	-	Ethanol	
Surface Emissive Power	kW/m^2	52	HSA LUP guidance for Class 1 materials
Pool size	m^2	2450	Area of Bund
Mass of material	tonne	61.5	Contents of Tank
Mass of fuel involved	ton	61.5	Worst case assumption
Equivalent diameter	m	50.5	-
Maximum heat exposure duration	s	75	HSA LUP guidance for long duration fires including pool fires (HSA, 2010)
Height of receiver	m	1.5	Assumed
Height of confined pool above ground level	m	0	At ground level
Wind speed	m/s	5	From HSA Land Use Planning Guidance
Wind direction	deg	240	From wind rose for Dublin Airport synoptic meteorological station, the nearest weather station for which long term average weather data is available

Table 7-2 *Inputs for Bunded Pool Fire calculations*

7.2.1.1 Bunded Pool Fire Consequences

Figure 7-6 illustrates the Thermal Radiation *vs* Distance and Figure 7-7 illustrates the Probability of Fatality Outdoors *vs* Distance. The thermal radiation contour corresponding to the threshold of fatality, 4.1 kW/m^2, is illustrated on Figure 7-8. The contour is the radiation level for the prevailing wind direction where the effect zone is the radiation level for all wind directions. Distances to mortality levels are summarised in Table 7-3.

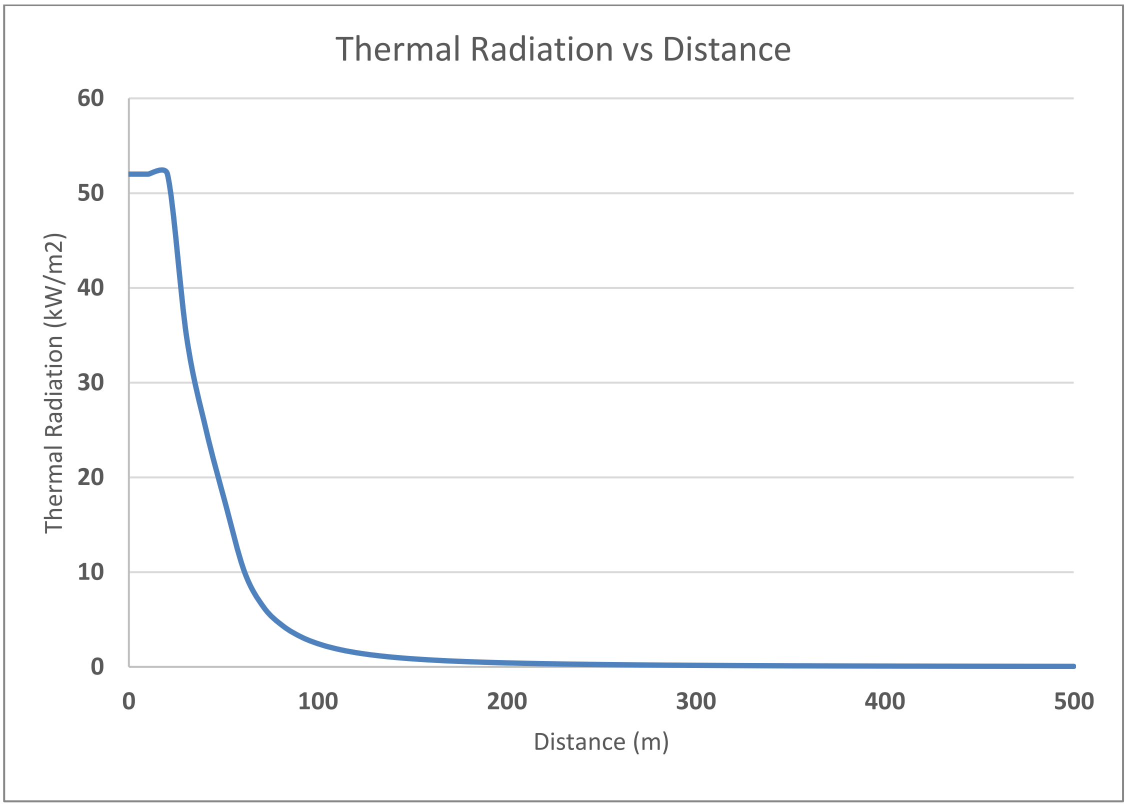


Figure 7-6 *Bunded Pool Fire: Thermal radiation vs Distance*

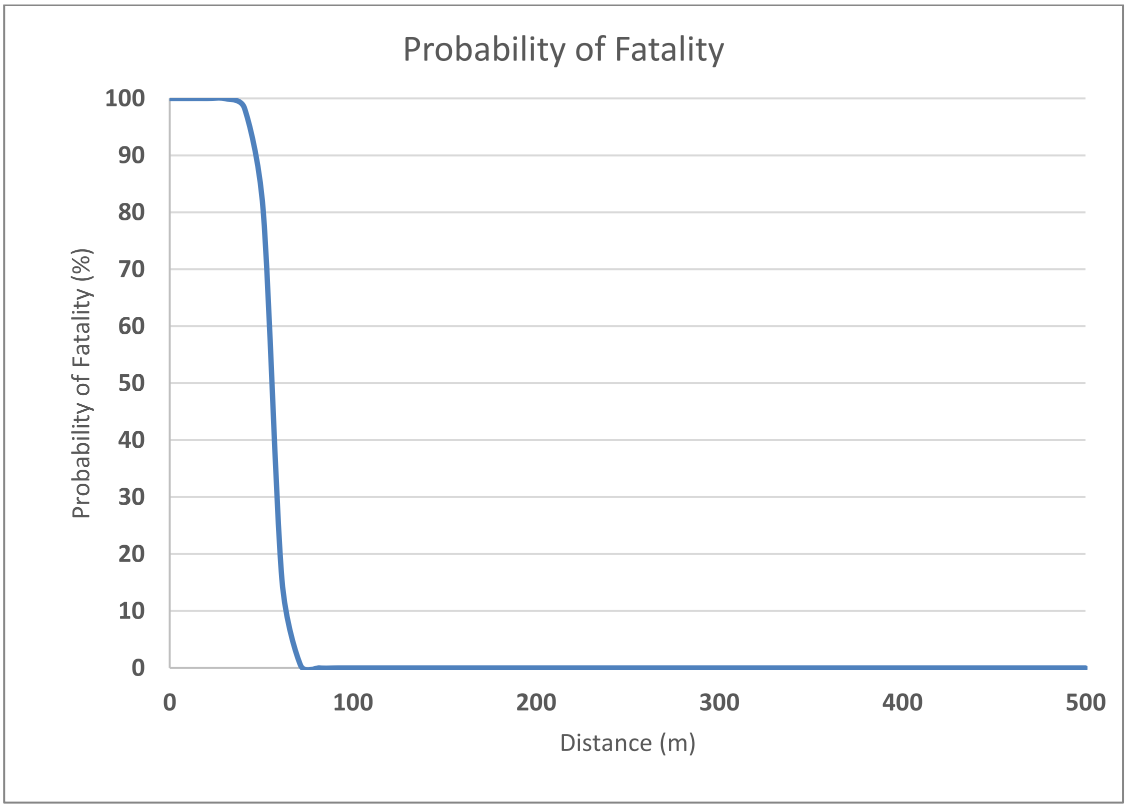


Figure 7-7 *Bunded Pool Fire: Probability of Fatality Outdoors vs Distance*

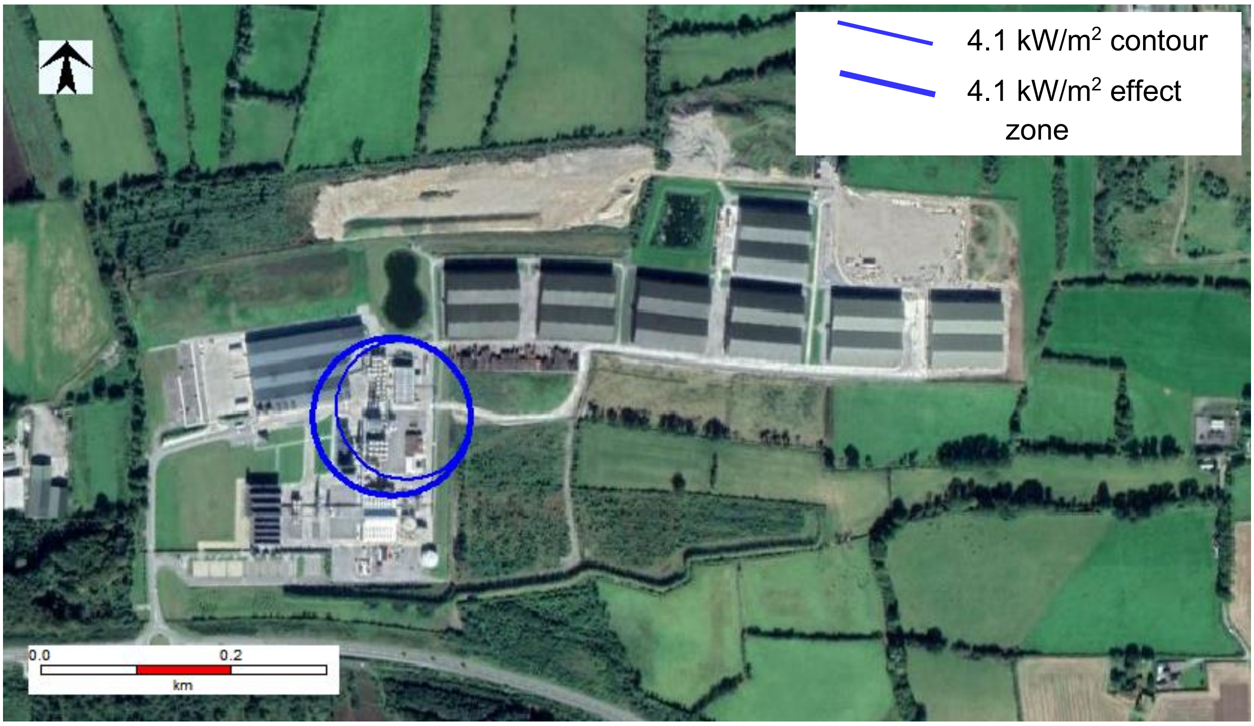


Figure 7-8 *Bunded Pool Fire: Thermal Radiation Contours*

Criterion	Thermal Radiation Level	Distance (m)
	kW/m^2	Windspeed 5m/s
Threshold of Fatality	4.1	79.1
1% Mortality Outdoors	6.8	70.0

Table 7-3 *Bunded Pool Fire: Distances to Thermal Radiation Endpoints*

In the event of an ethanol pool fire in the bund the following is concluded:

- The proposed residential development is 1,140 m from the spirit receiving tank
- Thermal radiation levels corresponding to the threshold of fatality (4.1 kW/m^2) extends 79.1 m from the spirit receiving tank and has no expected effect on the proposed development

7.2.2 Unbunded Pool Fire

In the event of rupture of the Receiving Tank (and bund overtopping) there is the potential for the released material to form a pool which on ignition could result in an uncontained pool fire.

7.2.2.1 Uncontained Pool Fire Model Inputs

It is assumed that 50% of the released liquid will overtop the bund (based on HSA COMAH LUP Guidance, 2010).

The worst case event is taken to be a circular pool fire located adjacent to the storage bund (i.e. due to bund overtopping or bund failure). The radius (R) of the fire is taken to be given by:

$R = 6.85\ V^{0.44537}$

with R in metres and V (volume of liquid in pool) in cubic metres, subject to a maximum diameter of 100 m (which occurs when V = 87 m^3), which should not normally be exceeded (unless there are special circumstances).

For the Receiving Tank, the overtop volume is 39 m^3 (30,771 kg), therefore the maximum pool diameter is taken as 70 m. The pool fire is centred at a distance of 50 m north east of the bund, this is in the direction of the proposed development and would be the worst case scenario.

The pool fire model in Phast 8.22 modelling software was used to model the consequences of a 70 m diameter pool fire involving ethanol (modelled with a SEP of 52 kW/m^2 as set out in the HSA LUP guidance).

The receiver height was specified as 1.5 m. As per HSA policy (HSA, 2010), calculations were undertaken for 5 m/s wind speed and radiation levels are calculated in the downwind direction. Thermal dose and probability of fatality is based on a 75 s exposure duration.

7.2.2.2 Uncontained Pool Fire Thermal Radiation Consequences

Pool Fire modelling results are presented in Table 7-4.

Thermal radiation	Pool Fire Results – Ethanol uncontained pool fire
Combustion rate (kg/s)	90.8
Flame tilt (deg)	39.8
Length of the flame (m)	35.7

Table 7-4 *Uncontained Pool Fire: Modelling results*

Uncontained pool fire consequence modelling results are illustrated on the following figures:

- Figure 7-9 Thermal radiation vs Distance
- Figure 7-10 Probability of Fatality Outdoors vs Distance

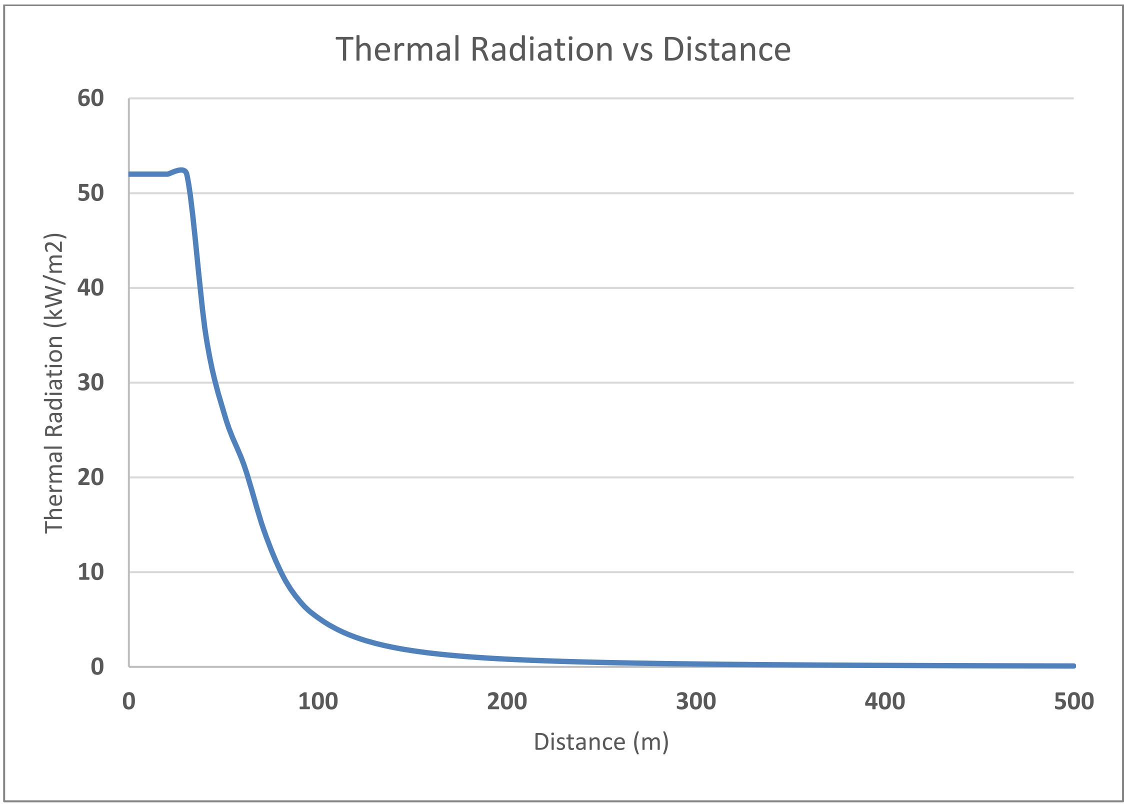


Figure 7-9 *Uncontained Pool Fire: Thermal radiation vs Distance*

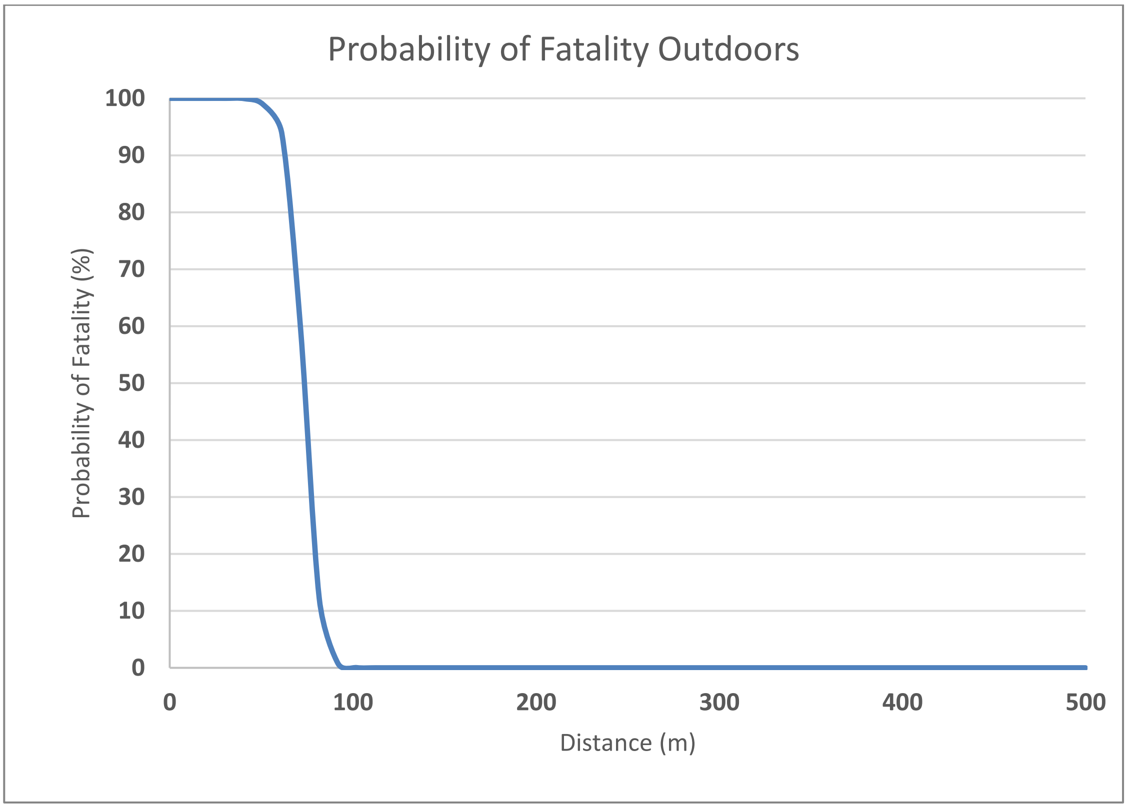


Figure 7-10 *Uncontained Pool Fire: Probability of Fatality Outdoors vs Distance*

Figure 7-11 illustrates the thermal radiation contours corresponding to the threshold of fatality. Table 7-5 summarises the results from an uncontained pool fire.

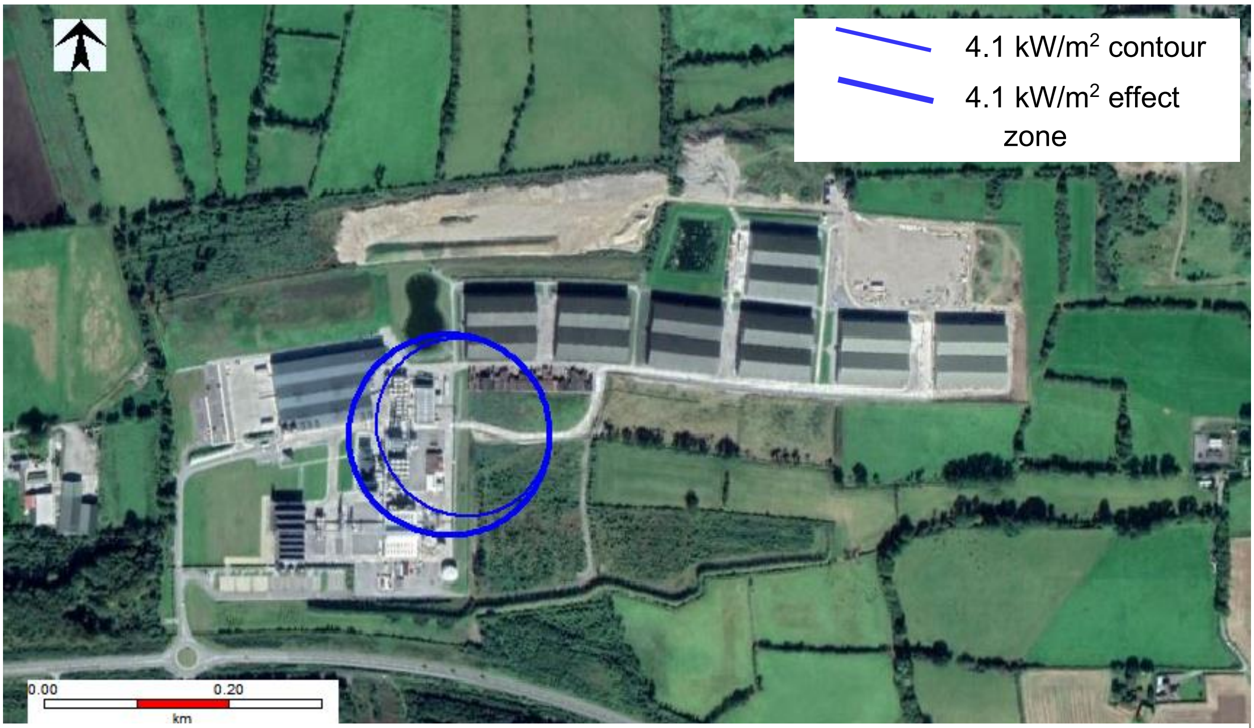


Figure 7-11 *Unbunded Pool Fire: Thermal Radiation Contours*

Criterion	Thermal Radiation Level	Distance (m)
	kW/m^2	Windspeed 5m/s
Threshold of Fatality	4.1	103.1
1% Mortality Outdoors	6.8	91.0
10% Mortality Outdoors	9.23	82.7

Table 7-5 *Summary of results from uncontained Pool Fire*

In the event of an unbunded ethanol pool fire the following is concluded:

- The proposed residential development is 1,090 m from the centre of the pool fire
- Thermal radiation levels corresponding to the threshold of fatality (4.1 kW/m^2) extends 103.1 m from the centre of the pool fire; therefore, there is no expected effect on the proposed development.

8.0 FREQUENCY ANALYSIS

As outlined in Section 3.1 herein, the HSA recommends the use of conservative frequency values for a small number of representative major accident scenarios, for land use planning assessments (HSA, 2010). Table 8-1 outlines the frequency value for each major accident scenario.

Major Accident Scenario	Frequency Value
Warehouse Fire	1×10^{-4}
Unbunded Pool Fire	1×10^{-4}
Bunded Pool Fire	1×10^{-3}
Vapour Cloud Explosion	1×10^{-4}

Table 8-1 *Frequency values for Major Accident Scenarios*

9.0 QUANTITATIVE RISK ASSESSMENT

9.1 Land Use Planning Risk Contours

Risk is the product of frequency and severity (or consequence). The frequency of the major accident scenarios is outlined in Section 8.0. The consequence results are detailed in Sections 6.0 and 7.0.

TNO RiskCurves Version 1031 modelling software was used to model the risk contours for the establishment.

The scenarios comprise a Warehouse fire in each compartment, Pool fire (bunded and unbunded) and confined VCE within the Ethanol Receiving tank.

The consequence results, frequencies of major accident hazards and Dublin Airport wind speed and frequency data (see Figure 4-1) were input to the software.

The HSA has defined the boundaries of the Inner, Middle and Outer Land Use Planning (LUP) zones as:

10E-05/year	Risk of fatality for Inner Zone (Zone 1) boundary
10E-06/year	Risk of fatality for Middle Zone (Zone 2) boundary
10E-07/year	Risk of fatality for Outer Zone (Zone 3) boundary

Risk contours for the proposed establishment corresponding to the boundaries of the inner, middle and outer risk-based land use planning zones are illustrated on Figure 9-1.

Figure 9-1 Individual Site Risk Contours

The following is concluded for Warehouse fire, Pool fire and explosion scenarios:

- Individual risk contours corresponding to the boundaries of the inner, middle and outer risk-based land use planning zones do not extend to the proposed development site.

10.0 CONCLUSION

AWN Consulting Ltd. was instructed by Steinfort Investments Fund to complete a COMAH Land Use Planning assessment for a proposed residential development in Tullamore, Co. Offaly.

The proposed development falls within the consultation distance of whiskey distillery and warehouse facility, William Grant & Sons. The distillery is a Lower Tier COMAH establishment and is subject to the provisions of the European Communities (Control of Major Accident Hazards Involving Dangerous Substances) Regulations, S.I. No. 209 of 2015. The 2015 COMAH Regulations place restrictions on land use planning on the types of development that can take place in the vicinity of COMAH establishments.

The Land Use Planning assessment was completed in accordance with guidance published by the HSA (HSA, 2010). The consequences of the major accident scenarios; warehouse fire, pool fire (bunded and unbunded) and vapour cloud explosions were modelled using PHAST version 8.22 and TNO Effects Version 10 modelling software.

Scenario	Consequences	Distance to proposed development (m)	Impacts at proposed development	Frequency
Warehouse Fire	Worst case 78 m to thermal radiation corresponding to the threshold of fatality (4.1 kW/m^2)	490	No expected impact	1E-04 per year
Warehouse Fire	Worst case CO_2 SLOD not reached	490	No expected impact	1E-04 per year
Bunded Pool Fire	Worst case 79.1 m to thermal radiation corresponding to the threshold of fatality (4.1 kW/m^2)	1,140	No expected impact	1E-03 per year
Unbunded Pool Fire	Worst case 103.1 m to thermal radiation corresponding to the threshold of fatality (4.1 kW/m^2)	1,090	No expected impact	1E-04 per year
VCE	Worst case 29 m to overpressure corresponding to 1 % fatality outdoors	1,140	No expected impact	1E-04 per year

TNO Riskcurves Version 10.1 modelling software was used to model the risk-based land use planning contours for William Grant & Sons distillery. It is concluded that the site individual risk contours do not extend to the proposed residential development.

In conclusion, the major accident scenarios discussed in this report have no expected impact on the proposed residential development.

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